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ABSTRACT

A six-year project providing training for prospective elementary school science teachers is described. Phase one, a period of three years, involved a longitudinal study of a pilot group of students as they encountered science content and science teaching methodology, coupled with early and continued field teaching experiences. In the final three years, the project participants were involved in their senior-level student teaching experiences and their post-college teaching assignments. The major objective of the project was to institute a pilot program in the undergraduate preparation in science for elementary teachers leading to the development of a six-semester integrated science-methodology course coupled with early and continued elementary school teaching experience. Inquiry training beginning with basic and simple scientific concepts was the fundamental method of instruction. Included in this report are course outlines for each semester and evaluation of the project. Tests and checklists used in the project are appended. (JD)

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UPSTEP

AN INTEGRATED APPROACH TO THE SCIENCE PREPARATION OF PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

SP012 931

U.S. DEPARTMENT OF HEALTH,
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PURDUE UNIVERSITY UPSTEP PROJECT

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PREFACE

This brochure is a capsulation of a six year project (1972-78) entitled "An Integrated Approach to the Science Preparation of Prospective Elementary School Teachers." This project was funded by the National Science Foundation under the Undergraduate Pre-Service Teacher Education Program (UPSTEP). The first three years of the project (Phase I) was concerned with a longitudinal study of a pilot group of prospective elementary teachers as they encountered science content and science teaching methodology coupled with early and continued field teaching experiences.

The last three years of the project (Phase II - 1975-78) was concerned with the continued implementation and dissemination of the goals of the project. In this interim, the project participants were involved in their senior-level student teaching experiences and their post-college teaching assignments. During this interval, a concerted effort was directed to the translation of the goals of the project by the participants into inquiry-learning situations for and with children.

Why UPSTEP?

In 1955 the National Science Foundation was advised, " . . . the most urgent need in the area of education in the sciences is help for the teachers of today." The teachers were eager; a few "summer institutes" had been successful, and the funds were limited. So in-service education was emphasized. Catalytic effects were expected: One of the primary goals listed for the Academic Year Institutes in 1957 was "to encourage effort on the part of American universities and colleges to develop and offer as part of their regular programs more effective plans for training in-service and potential science teachers."

It happened - rarely. Ten years later, many new teachers still had never seen the equipment used in teaching Science - A Process Approach or PSSC. It began to appear that "in-service" training was becoming another part of the training needed by all teachers of school-level science.

Perceptive observers asked whether better initial preparation (pre-service) might in the long run be much less expensive. The observers also began to list the additions and deletions needed to improve science teacher preparation:

Additions:

1. A special kind of recruiting that would start prospective secondary teachers as freshmen.

   Elementary teaching students and science students select their majors as freshmen - Wouldn't early recruiting be of equal benefit to "secondary science" majors?

2. Bring critic teachers (supervising teachers) into the teacher education program as full collaborators, for their contributions and influence are usually greater than that of any college faculty member.

3. Take steps to assure that teachers are able to handle "new" science courses necessary in their discipline or at their teaching level.

4. Change college level science courses and curricula for pre-service teachers to bring the courses up to date and to increase their effectiveness.

5. Arrange programs so that prospective teachers will have early responsibility experience in classroom teaching.

Deletions:

1. Avoid the sharp cutoff of contact between newly-graduated teacher and college faculty. The faculty especially can benefit by keeping in touch with the real world.

2. Avoid the separation of teacher training from science. The teacher is one person. The training should be based on one general philosophy.

The National Science Foundation listed these topics in its announcement of the Pre-Service Teacher Education Program in 1969. The Program, promptly dubbed "UPSTEP", has since received over 200 proposals and has supported 28 projects.

Proposals leaned heavily toward doing the faculty's regular thing: changing courses and curricula.

With the decline in school attendance, demand for teachers dropped, and so did all reference to recruiting prospective teachers.

Critic teachers were part of many projects - but after the projects ended, only a few teachers retained their positions with the college or university teacher training program.

The projects that succeeded have shown the value of some of the ideas:

Early responsible teaching experience has been valuable wherever it was tried. Even for those who dropped out of the program - averaging 5% to 10% - the "selection out" of teacher training saves one to three years of college work. More importantly, early teaching reinforces the decision for most pre-service teachers. Another benefit is that there is increased contact between school and university faculties - and prospective teachers enhance that communication by carrying requests from the school and by borrowing equipment and materials and by bringing up-to-date information from the college.

Changing courses and curricula - the faculty pastime - may turn out to be highly valuable if new kinds of teaching are being tried, rather than the usual changes in subject matter. The most effective approach developed with UPSTEP support might be called basic science process. It is an "inquiry" program that deals with science knowledge by asking, "Why do we believe . . ., how do we know . . . and what is the evidence?" Mathematical reasoning is mastered through its use where appropriate in answering the question. The course is designed so that students are challenged at their own academic and Piagetian intellectual levels.

One of the least expected revelations of the work of designing this course is this finding: When attempting new science instructional units (from SCIS, for example) the responses of college juniors who are prospective elementary teachers does not differ from the response of 10-year old students. Thus, it is clear that one does not learn science process by being told about it or by reading about it. The beginner in science inquiry starts at the beginning, regardless of his or her age.

The most tangible change resulting from UPSTEP grants in several institutions is a science teaching resource center. There are several varieties, but all contain equipment from several different courses and curricula, that pre-service and in-service teachers may borrow. Faculty members use the materials for demonstrations, or the center may be used for classes. And of course, graduate students make use of the resources that are assembled in one place. The Center is best when it becomes a meeting place of pre-service and in-service teachers and all the other educational professionals. Frequently, we find it serves the further purpose of providing the common ground needed to bring science mathematics and education faculties together.

The principal acheivement of UPSTEP has been to demonstrate the value of a few programs that have succeeded in the preparation of teachers more competent than the new graduates of a decade ago.

The principal challenge UPSTEP now faces is to foster widespread adoption of the innovative approaches that worked so well for their authors. We have therefore shifted gears and will be testing some adoption mechanisms along with a continuing search for new and better ways of teaching science teachers.

Donald C McGuire

Donald C. McGuire, Project Manager
Experimental Projects and Developing
Programs Group
National Science Foundation
Washington, D. C.

Academic year 1975-76 is Purdue's fourth year in UPSTEP. The students who started in the Fall semester, 1972 are now student teachers. Preliminary results of extensive evaluation studies provide substantial evidence of UPSTEP'S influence on their performance in the classroom. It seems clear that at Purdue we are demonstrating the efficacy of two fundamental precepts: prospective elementary teachers can and do learn to "do" science and by so doing are able to lead children through the same kind of inquiry-oriented encounters.

The necessary ingredients are easy enough to list; they are harder to realize.

1. College science faculties must be willing to forsake some topic coverage in favor of science inquiry as a worthy goal.
2. Knowing the style of cognitive development of the learner is an essential diagnostic datum in arranging for his or her science experiences.
3. Science educators responsible for the formal pedagogical components of such a program must work closely with colleagues who teach the science courses.
4. Extensive and carefully structured field experience in which the students can practice teaching is an extremely valuable component.

All of these ingredients require commitment: A commitment of time, of resources, and of energy. Their application necessitates a much greater than typical commitment to an undergraduate instructional program than many universities expect to make. There are no easy or cheap means of providing a high quality program in teacher education.

UPSTEP is demonstrating how to make a quantum improvement in the quality of certified teachers. It remains for the educational community and the citizenry to insist on its widespread implementation.

R. B. Kane

R. B. Kane
Chairman, Department of Education and
Director, Teacher Education
Purdue University

Teacher training has always been a complex undertaking. No other profession is as well known to so many and yet understood by so few. The union of content acquisition plus the translation of this into appropriate teaching lessons augmented by field teaching experience has been a persistent problem in teacher preparation.

Through the cooperation of the National Science Foundation (UPSTEP), a trichotomous approach to the improvement of the undergraduate preparation of elementary teachers in science was undertaken at Purdue University. This approach integrated science content to continued methodology to early and continued field experience. Through this model teacher education program, prospective elementary teachers were taught science through inquiry. Continued methodology was constantly tied to previously acquired science content and translated into viable teaching lessons. Teaching experience, over a four year period, was gained through practice and direct involvement with elementary children.

Evidence gathered during the first three years of the UPSTEP project strongly suggest that this approach provides a unified, humanistic approach to the preparation of prospective elementary teachers. The UPSTEP model for teacher preparation has broad implication for the improvement of teacher education at Purdue University and other institutions involved in teacher education who wish to examine this model.

R. L. Ringel

Robert L. Ringel
Dean, School of Humanities,
Social Science and Education

PURDUE UNIVERSITY UNDERGRADUATE PRE-SERVICE TEACHER EDUCATION PROGRAM (UPSTEP)

What Instigated the Purdue UPSTEP Project?

At Purdue University, as part of the undergraduate curriculum, prospective elementary teachers are required to take fifteen hours of science. This involves three mandated science courses (Biology 205, Biology 206, and Physics 210) and two elected science courses. The most popular elected science courses by prospective elementary teachers are meterology, astronomy, physical geology, and historical geology. Rarely do prospective elementary teachers choose to engage in another physics course or add a course from the chemistry area. This traditional approach to fulfilling the science requirement is then capped by an elementary science methods course given in the senior year prior to student teaching.

This approach has some serious shortcomings. They are as follows:

> This approach to the science preparation of prospective elementary teachers was fragmented. In many cases it was irrelevant to either the discipline or the teaching of science in the elementary school. For many students this resulted in nothing more than memorization of the minutia of science. The five courses in science did not "hang together," for no story line bonded these disciplines. The students exited with a disjointed view of what science is. Freshman elementary education majors can be characterized as having a strong negative attitude toward science when they arrive at the university. The range of disaffection runs from boredom and dislike to apprehension and fear. Unfortunately, exposure to college level science courses did nothing to improve this attitude. In fact, the negative attitude was often reinforced.
>
> Prospective elementary teachers are introduced too late to elementary method courses (usually in their junior and senior year).
>
> And, prospective elementary teachers in most cases, have little, if any, direct contact with children. Many prospective elementary teachers approach student teaching with fear and trepidation.

Prospective elementary teachers exposed to the spirit and intent of the national elementary science curriculum projects, such as Science - A Process Approach (S-APA), Science Curriculum Improvement Study (SCIS), and Elementary Science Study (ESS) have changed from skeptics of science instruction for elementary school children into believers of science instruction for elementary school children. The naturalness of instruction in the processes of science (S-APA), the structure and order of the process plus content (SCIS), and the creativeness of the Elementary Science Study units made science palatable for prospective elementary teachers. Science thus presented in the science methods course was reported by students as interesting, relevant, and thoroughly enjoyable. The intrinsic power of inquiry was strongly evidenced. And, indeed, there was a joy in the realization of one's ability to pursue an investigation, gather data, control variables, and conclude something based on one's confidence in one's observations. Students wondered why they were not able to garner this same set of experiences from the required college-level science courses.

Through the cooperation of the National Science Foundation a pilot Undergraduate Pre-Service Teacher Education program was initiated. The pilot program is to culminate in a model program for the preparation of elementary teachers at Purdue University. Subsequently, it is planned that this program could be offered as a model for possible adoption by other teacher training institutions.

Objectives of the Project

The Purdue University UPSTEP project has as its major objective:

To institute a pilot program in the undergraduate preparation in science for elementary teachers leading to the development of a six-semester integrated science-methodology course coupled with early and continued elementary school teaching experience.

Additional objectives are:

To identify a conceptual framework for the integration of basic science around the theme "Man and His Environment."

To select content according to the following criteria:

a. the facilitation of intellectual development by the students;

b. the intellectual power or significance of the concept;

c. the probability of the material being included in an elementary science program;

d. the social significance and relevance of the material to the students taking the course.

To provide experiences for prospective elementary teachers consistent with the nature of scientific inquiry, resulting in an understanding of the processes of science as demonstrated by performances in relation to carefully structured behavioral objectives.

To increase the number of undergraduates in elementary education who elect to acquire an endorsement in elementary science education.

To determine if teacher attitude toward the teaching of science is affected by an integrated approach to science instruction at the undergraduate level.

Program Description

The Purdue University UPSTEP project was initiated in the fall, 1972, involving 63 freshman students. These students were randomly selected from a larger group of students, all of whom expressed some interest in an elementary education major.

To rectify some of the shortcomings of the fragmented approach to the undergraduate science preparation of prospective elementary teachers, it was decided that the elementary science methods course would be offered first and the subsequent five science courses would be presented through an integrated science approach. The major theme or story line that pervaded throughout these five courses was "Man and His Environment" as related to "Survival in the face of Change." The first course in the five-course science sequence presented units designed to lead the students through exploration, invention, and discovery toward an understanding of the concept of a population and the formulation of a model of population growth. This topic was followed by a unit designed to guide the students through inquiry to the invention of the Mendelian model of the gene. This study led subsequently to their recognition of sources of genetic variation (mutation, recombination) and of the concept of genes in populations. Finally, a population was followed through several generations and evidences for equilibria or shifts in gene frequencies were observed.

Involvement with the students in their first course demonstrated conclusively that inquiry into the simplest concepts of science proved to be a rigorous task. Although the students were enthusiastic about the course and recognized the importance of being taught science through inquiry, most students experienced great difficulty in generating original ideas from their own experiences. Particularly revealing were the early results of Piagetian task analysis which revealed that approximately fifty percent of the students in both the experimental and the control group were at the concrete stage of intellectual development and another twenty five percent were in the midst of transition to formal thought. It is not the discipline that determines what should be taught, but rather where the students are intellectually. Recognizing this, it was realized that many of the important concepts of science are too abstract for meaningful inquiry. In fact, materials from the elementary science projects often provide excellent examples of appropriate inquiry activities for prospective elementary teachers.

With the experiences of the first year as a guide the second and third semester courses were designed to help students generate a better understanding of their physical environment. These courses, while entitled physics and chemistry, address themselves not only to the content of science, but principally to the integration of scientific thought as directed toward the pursuit of understanding. All knowledge was presented in an inquiry manner. Inquiry was orchestrated about the questions, "How do I know Why do I believe and, What is the evidence?"

The content of the physics courses was selected to guide the students toward an understanding of such things as the difference between a chemical and a physical change, conservation of mass and properties of matter. These activities formed the basis for the building of a particulate model of the atom. In addition, a year long sequence of observations enabled students to understand why we believe in the sphericity of the earth and to develop a model of our solar system and the universe. The ESS unit Batteries and Bulbs formed the basis of a unit designed to develop operational definitions of such things as circuits, resistance and related electrical phenomenon. Finally, inquiry activities were designed considering the concept of motion from Aristotle to Newton. Materials from Professor Arnold Arons' (University of Washington) adaptation of the Introductory Physical Science and the Project Physics Course were utilized in these courses.

The fourth and fifth semester science courses consisted of an integration of all disciplines. Special emphasis was given to biological and geological problems as they related to ecological and environmental concerns. A major emphasis was placed on outdoor activities including extensive field work designed to develop a secure understanding of the ecosystem model. Finally, the basic facts of sex and drug education were presented utilizing individualized audio-tutorial instruction (S. Postlethwait, Purdue University). Sex and drug education were the only topics presented in an expository manner. Inquiry teaching pervaded all other instruction.

Prior to the five science courses, students received a general introduction to the methods of teaching elementary science to children. This curricular rearrangement served several purposes: 1) it provided a background at the freshman level for the early engagement of prospective elementary teachers with children in teaching-learning situations, and 2) it provided an opportunity for prospective elementary teachers to reinforce their commitment to elementary education or, based on this contact, the opportunity to select an alternate career early in their scholastic program. This approach is deemed a vital component of the project.

The methods course provided a broad foundation to teaching with heavy emphasis on the philosophies of the major national curriculum programs such as S-APA, SCIS, and ESS. Prospective elementary science teachers were introduced to performance objectives, sequencing, microteaching, etc. The students were also exposed to a practical skills technique experience. In concert with the notion of students "out of their seat and on their feet" doing "hands-on" science, prospective elementary teachers learned to solder, work with glass, use an electric drill and saw, etc. These skills were utilized by the students in the construction of physical constructs such as electric boards, terrariums, balances, etc.

Concurrent with the subsequent on-going science content, continued methodology was tied to on-going teaching experiences with children.

This approach constantly reinforced the notion that "how to teach" is every bit as important as "what to teach." Thus, the general methods course and five science courses welded content to methodology to experience.

Teaching experiences in the first year were limited to several critiques of "model" teaching situations using 3rd grade children from a nearby public school. In the first semester of the second year, the prospective science teachers were assigned to teach in the primary grades (first and second grades). This was expanded during the second semester to include the intermediate grades (fourth through sixth grade). They taught six, one-half hour to one hour lessons each semester. Each lesson was preceded by a one hour planning session with one of the staff members. Each lesson was video taped. The week following the teaching stint was reserved for a one hour critique of the teaching lesson. Lessons were selected from S-APA, SCIS, and ESS materials. At the end of the second year the population of the learning groups was progressively increased from one or two to ten students. Thus, by the end of the second year each participant had experienced teaching at all grade levels (one through six) and had begun working with large groups of children. Having had this varied grade level experience, the participants were directed to select a grade level of their choice to fulfill the third year teaching experience. Traditionally, eighty to ninety percent of the prospective elementary teachers elect to teach third grade and lower. Over fifty percent of the UPSTEP participants elected to teach fourth grade and above. It is believed that this shift was due to the varied experiences (first through sixth grade) acquired over the two year period. As always, every attempt was made to develop within the prospective elementary science teachers a spirit of self analysis and general acceptance of constructive criticism.

Accepting that teachers will teach as they have been taught, a constant model of inquiry teaching was put before the prospective elementary science teachers. Stress was on the development of science out of direct experiences in lieu of exposition of the facts of science and memorization of the same. Students were engaged in the processes of science and were led to discovering the usefulness of models and generalizations. The emphasis was on the ideas of science rather than the vocabulary of science. The students were constantly challenged through discussions and questioning to a revision of faulty thinking rather than being told their answers were incorrect.

Training for Inquiry Teaching

Recent national curriculum projects in elementary school science have resulted in the availability of excellent materials for teaching elementary science. If properly taught and implemented, any of these projects (S-APA, SCIS, ESS) would result in excellent instruction in science. While individually different, a common denominator among these elementary science projects is the idea of learning through inquiry. What is needed are prospective science teachers who can teach science to children through inquiry.

At the college level, "traditional" science courses presented through inquiry are sorely lacking. It is imperative that prospective science teachers have experiences from which they can model their teaching of science. The integrated five semester science sequence at Purdue University was structured using the inquiry approach. This method of instruction has apparent consequences. If science is to be presented through exploration, invention, and discovery, rather than through lecture and memorization, time must be viewed in a new perspective. Only by allowing the students time to make mistakes, to experience the frustration of insufficient knowledge, and to sharpen their ideas through peer interaction and class discussion can students experience the personal satisfaction that arises from achieving understanding through their own intellectual efforts. If there is a joy to sciencing, this is it.

The approach of insisting on the pursuit of understanding by students makes the uncovering of information more important than the covering of information. This approach restricts the content of a course. Course content reduction is not arrived at out of a disregard for the value of information, but rather it stems from a full realization of how fundamental time is for allowing the inquiry process to proceed until understanding is achieved. A good model of inquiry teaching cannot sacrifice the time required for understanding to the demands of comprehensive coverage.

Humanizing the Undergraduate Science Preparation of Prospective Elementary Teachers

Prospective elementary science teachers enter universities with little or no experience in making observations, basic laboratory skills, or knowledge of how to apply elementary mathematics to experimental results. They also lack the ability to independently and creatively correlate an abstract idea with a concrete situation. Exposure to 15 hours of "traditional" science at the college level does little to obviate these deficiencies. Student teaching experiences usually supported this inadequacy of preparation in that the students' behavior supported the old adage that "teachers will teach as they have been taught." Inevitably they resorted to a presentation of the facts of science with little or no attention to how they have been generated. Through the provision of a model of inquiry teaching that endured for a three year period, plus the continued emphasis on content acquisition via an inquiry approach, and through on-the-job teaching experience concommitant with constant evaluation against an inquiry model, improved inquiry teaching in the elementary school has resulted.

While basically concerned with the science preparation of prospective elementary science teachers, attention has been given to other areas that impinge on "good" teaching. Students with recognizable problems in speech, composition, and handwriting were tested and remedial work was administered. It is recognized that students cannot improve in these areas through a crash program administered shortly before student teaching commences. Time is necessary to remove these deficiencies. Thus, remediation was initiated in the freshman year and where applicable, continued.

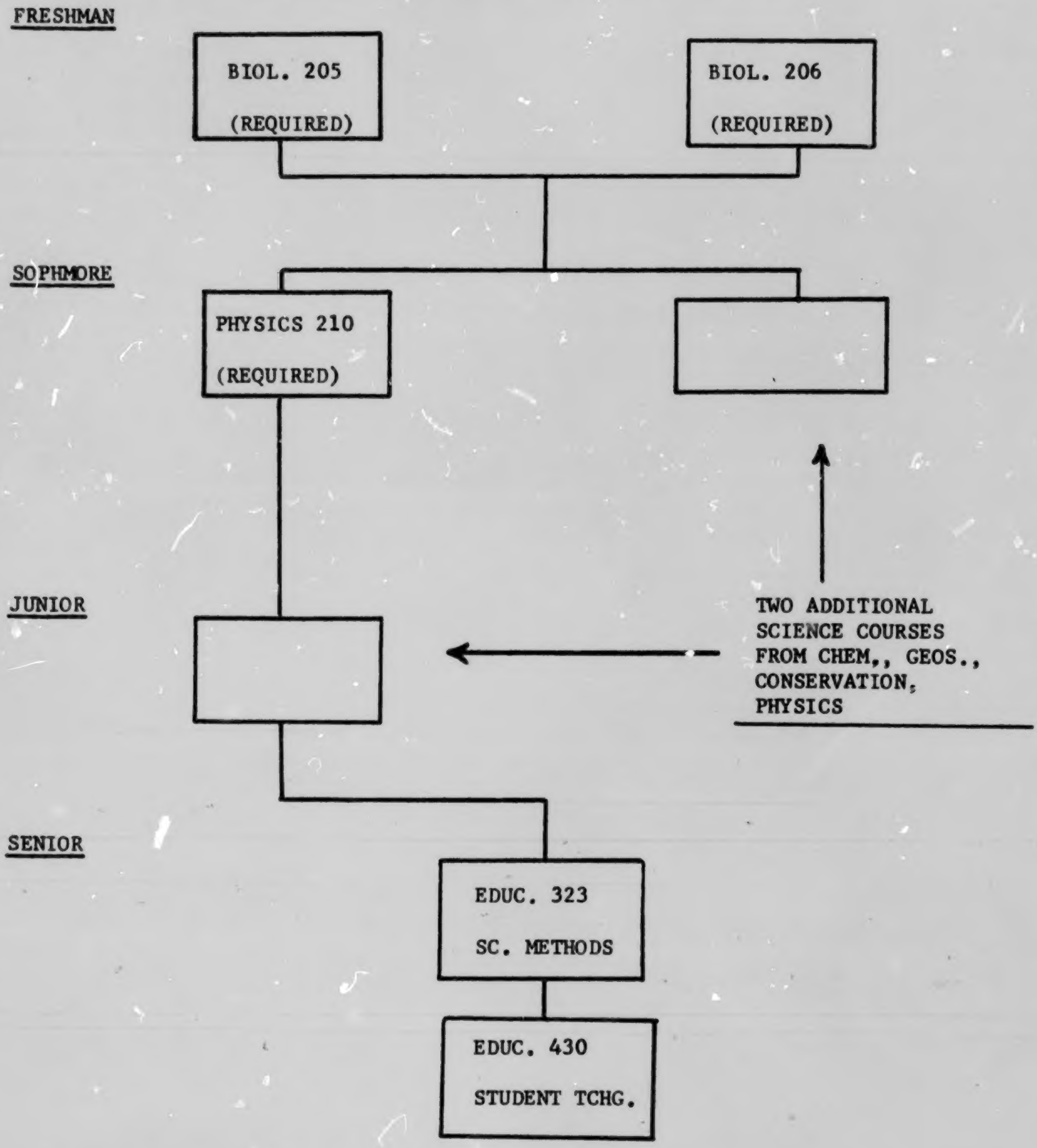
Most significant to the project is the fact that the staff remained with the students for the three year period. The staffs' roles varied from classroom instructors, monitors, administrators, evaluators of teaching experiences, to counselors. Nevertheless, the continued tie to the program was provided. This close association makes remediation, rather than mere identification of individual weaknesses, a reality. Counseling becomes an on-going, free wheeling process.

Some early favorable observations associated with the program are clearly in evidence. Students have become increasingly confident regarding their ability to solve problems in science. They attack problems with excitement and vigor. Inquiry has become an active part of their vocabulary, their actions, and their student teaching performances.

Negative attitudes toward science have been reversed as noted by continued positive statements about science from the majority of the students. This change is due in part to their successful intellectual development through cognitive experiences. In part, it is a reflection of the presentation of integrated science, the relationship of the science content to science methodology and to classroom teaching experience with children and the continuation of the same staff over a three year period.

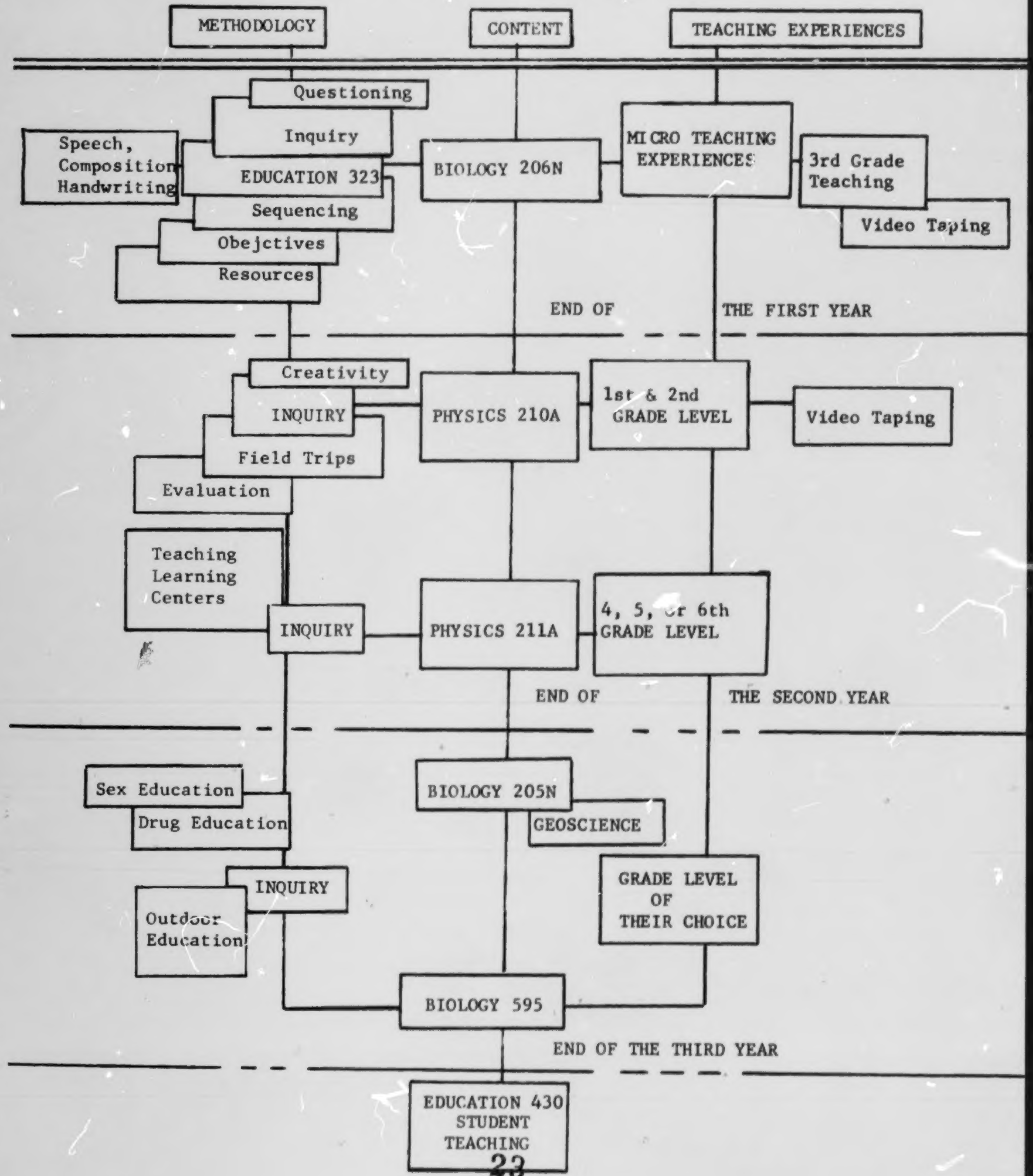
The spirit of inquiry promoted throughout the program was translated into effective inquiry teaching at the elementary school level. This program is not a cure-all for all that ails instruction in the elementary schools but it is a significant improvement. What a unique pleasure it is for instructors to be able to say with conviction to their students, "Teach as you have been taught; do as we say and do - Inquire!"

TRADITIONAL APPROACH TO FULFILLING THE SCIENCE REQUIREMENTS FOR ELEMENTARY EDUCATION MAJORS, PURDUE UNIVERSITY


FRESHMAN
BIOL. 205
(REQUIRED)
BIOL. 206
(REQUIRED)
SOPHMORE
PHYSICS 210
(REQUIRED)
JUNIOR
TWO ADDITIONAL SCIENCE COURSES FROM CHEM,, GEOS., CONSERVATION, PHYSICS
SENIOR
EDUC. 323
SC. METHODS
EDUC. 430
STUDENT TCHG.

EXPERIMENTAL APPROACH

UPSTEP PROJECT - PURDUE UNIVERSITY


METHODOLOGY
CONTENT
TEACHING EXPERIENCES
Questioning
Inquiry
Speech, Composition Handwriting
EDUCATION 323
Sequencing
Obejctives
Resources
BIOLOGY 206N
MICRO TEACHING EXPERIENCES
3rd Grade Teaching
Video Taping
END OF THE FIRST YEAR
Creativity
INQUIRY
Field Trips
Evaluation
PHYSICS 210A
1st & 2nd GRADE LEVEL
Video Taping
Teaching Learning Centers
INQUIRY
PHYSICS 211A
4, 5, or 6th GRADE LEVEL
END OF THE SECOND YEAR
Sex Education
Drug Education
INQUIRY
Outdoor Education
BIOLOGY 205N
GEOSCIENCE
GRADE LEVEL OF THEIR CHOICE
BIOLOGY 595
END OF THE THIRD YEAR
EDUCATION 430 STUDENT TEACHING

Evaluation

Phase I 1972-75. The experimental group consisted of 63 freshmen randomly selected from a group of approximately 300 students enrolled in Biology 205, "Biology for Elementary School Teachers". The remainder of the Biology 205 students served as the control group. The following examinations were administered to both groups.

a) Wisconsin Inventory of Science Processes
   Pretest (1972) and Posttest (1975)
b) Bratt Test of Attitude Towards Teaching and Teaching Science
   Pretest (1972) and Posttest (1975)
c) Sequential Tests of Educational Progress (STEP) - Science
   Pretest, Form 1A, 1972 and Posttest, Form 1B, 1975
d) Piagetian Style Tasks
   Fifty-four S's from the experimental and control group were tested. Pretest, spring, 1973; Posttest, spring 1974

Phase II 1975-77. The experimental program will continue to be evaluated by obtaining data from three general sources; 1) Student teachers (seniors) who have participated in the UPSTEP program (testing in progress - 1975-77), 2) In-service teachers (UPSTEP graduates - to be tested 1976-77), and 3) Elementary school students of the in-service teachers (UPSTEP graduates - to be completed 1976-77).

Pretest: Experimental and Control Groups, fall, 1975

a) Conceptual Systems, Test A (O. J. Harvey), fall, 1975
b) Teacher Concerns Checklist (F. F. Fuller), fall, 1975

Experimental Group only, on-going evaluation, 1975-77

a) Audio Tape Analysis
   Interaction Analysis Science Teaching (G. Hall)
b) Visual Analysis
   Inquiry Quotient Inventory (A. Lawson & A. De Vito)
c) Inquiry Tape Analysis

Elementary School Students

Science Teaching Checklist (M. Golman). To be administered 1976-77.

Posttest: Experimental Group

a) Conceptual Systems, Test B (O. J. Harvey), spring, 1977
b) Teacher Concerns Checklist (F. F. Fuller), spring, 1977

Sequential Tests of Educational Progress and The Wisconsin Inventory of Science Processes Evaluation

Of particular interest was the effect of Project UPSTEP on science achievement and on knowledge of scientific methodology. Science achievement for the experimental and control groups was measured by the science version of the Sequential Test of Educational Processes (ETS, 1957). This test, known as the STEP test, consists of 30 items dealing with science skills and abilities. Knowledge of scientific methodology was measured by the Wisconsin Inventory of Science Process (The Regents of the University of Wisconsin, 1967). This instrument, the WISP test, consists of 93 items which are concerned with the assumptions, activities, objectives, and products of science.

For each of these measures, group means were analyzed by means of a *t*-test (two samples, standard deviations equal but unknown) in an effort to answer the following questions:

1. Were the experimental and control groups equal with respect to the dependent variables at the outset of the project?
2. Did group means increase significantly over the course of the students' undergraduate careers within each group?
3. Was there a significant difference between the experimental and control group means at the end of the project?

In reporting the results of this analysis, means and specific *t* values will be reported whenever the difference between group means is significant. Associated with each *t* statistic will be a *p* value which indicates the probability that a difference of that magnitude could have occurred by chance (e.g., $p < .01$ indicates that such a difference could have occurred by chance only one time in a hundred).

Analysis of the STEP test data indicates that experimental and control group were equal with respect to science aptitude at the outset of the project. Prior to student teaching, the control group demonstrated a bearly significant increase in achievement in science (1972 $\bar{X} = 28.80$, 1975 $\bar{X} = 30.18$, $t\ (224) = 1.52\ p < .10$). However, the experimental group showed far greater achievement in science aptitude (1972 $\bar{X} = 28.25$, 1975 $\bar{X} = 32.50$, $t\ (91) = 5.96$, $p < .005$). Comparison of the 1975 STEP test means for the two groups shows the experimental mean to be significantly greater than that of the control group (experimental $\bar{X} = 32.50$, control $\bar{X} = 30.18$, $t\ (85) = 1.72$, $p < .05$). These results clearly support the hypothesis that the quantity of science content taught via the traditional science approach for elementary education majors is not as important as the quality of science covered in an integrated science approach taught through inquiry with understanding paramount to expansive science coverage.

Analysis of the 1972 WISP test data indicates that the control group was slightly more knowledgeable about scientific methodology than the experimental group at the outset of the program (control $\bar{X} = 56.73$, experimental $\bar{X} = 54.98$, $t\ (226) = 1.33$, $p < .10$). However, through the course of the traditional elementary science teaching curriculum, the control group failed to significantly increase their knowledge of scientific processes (1972 $\bar{X} = 56.73$, 1975 $\overline{X} = 58.09$). Yet the experimental group increased their scores on the WISP test dramatically (1972 $\overline{X} = 54.98$, 1975 $\overline{X} = 64.77$, $t\ (91) = 4.96$, $p < .005$). Furthermore, the 1975 WISP test mean of the experimental group was also significantly greater than the control group mean (experimental $\overline{X} = 64.77$, control $\overline{X} = 58.09$, $t\ (85) = 3.68$, $p < .005$).

To further establish the effects of the program, more conservative analyses of variance (ANOVA) were conducted on the WISP data. A 2 x 2 unequal cell ANOVA was run for the WISP scores with Method (UPSTEP Experimental vs. Control) and Time (pretest vs. posttest measurement) as major factors. A significant effect for time was found ($F = 13.45$, $df = 1/308$, $p < .005$) favoring posttest measurement. However, a significant Method X Time interaction ($F = 11.26$, $df = 1/308$, $p < .005$) was also found. A Newman-Keuls Sequential Range Test indicated that the two groups were equal with respect to WISP performance, but that the post-measurement scores for the experimental group were significantly greater ($p < .01$) than the control (see Figure 1).

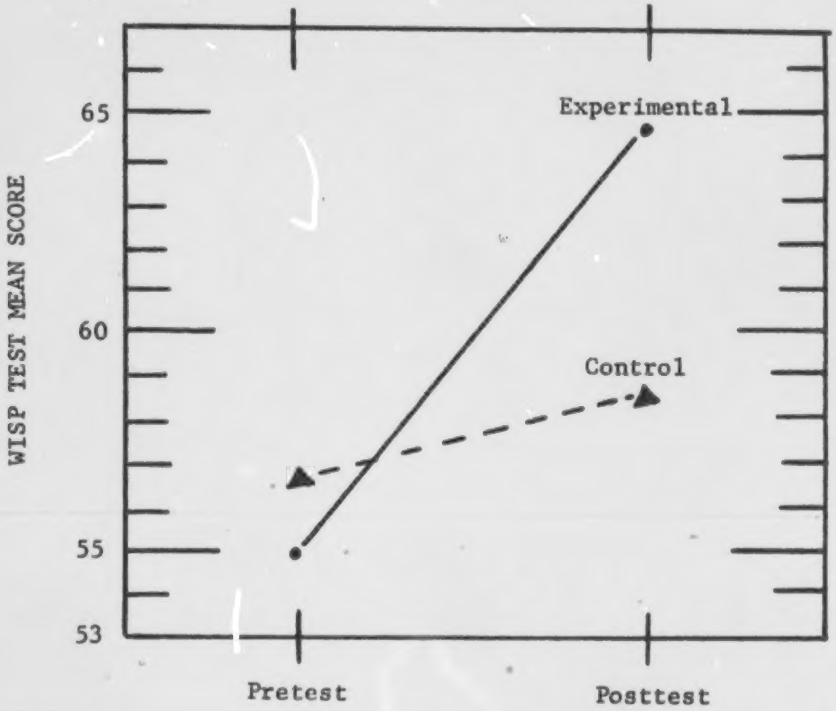


Figure 1
WISP Test:
Graph of Means

These results clearly support the hypothesis that the integrated inquiry science approach, in meeting the elementary education majors' requirements in science, does promote greater understanding of the assumptions, activities, objectives, and products of science then the traditional science approach currently implemented at Purdue University.

Bratt Test of Attitude Towards Teaching and Teaching Science

A major component of the UPSTEP project was the humanistic approach utilized throughout Phase I (1972-75) and the anticipated, continued application throughout Phase II (1975-77). This approach consisted of the utilization of a permanent cadre of staff members who, in a variety of changing roles, progressed with the participants through the program. The staff constantly addressed themselves to the continued marriage of content acquisition, to continued science methodology, to early and continued field experience with children. This continued staff involvement more closely matched staff responsibility to the end product--the training of outstanding elementary teachers in science. This continued, involved teaching with its continued close association with students and considerations given to individual strengths and weaknesses was studied to determine the impact on science-related attitudes. The instrument used for this part of the analysis was the Bratt Attitude Test (Bratt, 1973). This test, also known as the BAT test, consists of 60 intellectual and humanistic science and science teaching attitude statements. Response to the items is on a five-point semantic differential scale (strongly agree to strongly disagree). Intellectual attitude statements were based on knowledge pertaining to the teaching of science. Humanistic attitude statements measured emotional feelings towards the interaction between the teacher and student. Analysis procedures were the same as those used on the STEP and WISP tests.

Analysis of pretest measure indicated that there were no significant attitudinal differences between experimental and control groups at the outset of the study. However, posttest attitude scores for the experimental group were found to be significantly greater than those of the control group (experimental X = 21.30, control X = 17.19, t = 2.68, df = 100, $p < .005$). In fact, the traditional curriculum produced no change in the attitudes of control subjects (1972 $\overline{X}$ = 18.06, 1976 $\overline{X}$ = 17.19). In comparison, the experimental group demonstrated a significant increase in BAT scores (1972 $\overline{X}$ = 18.56, 1976 $\overline{X}$ = 21.30, t = 2.22, df = 91, $p < .02$). These results indicate (1) a crystallization of attitudes regarding knowledge of science and science teaching and (2) a marked trend towards more humanistic attitudes towards students for subjects in the experimental group.

In a fashion similar to the analysis of the WISP data, ANOVA's were conducted on BAT scores using the same factorial design as described in the previous section. Separate analyses were conducted on total scores as well as on intellectual and scientific subscales.

Analysis of BAT total scores showed no significant effects for either Method or Time. However, analysis of the scientific attitude subscales showed significant main effects for Method (F = 39.80, df = 1/330, $p < .001$) in favor of the experimental group and for Time (F = 240.21, df = 1/330, $p < .001$) in favor of posttest measurement). A significant Method X Time interaction was also found (F = 5.70, df = 1/330, $p < .05$). Newman-Keuls analysis of cell means showed that the improvement of attitudes towards science was far greater for the experimental group than for the control group (see Figure 2).

ANOVA of Humanitarian subscale scores also showed significant main effects for Method (F = 22.99, df = 1/330, $p < .001$) in favor of the experimental group and for Time (F = 42.37, df = 1/330, $p < .001$) in favor of posttest measurement. Figure 3 presents a graph of cell means.

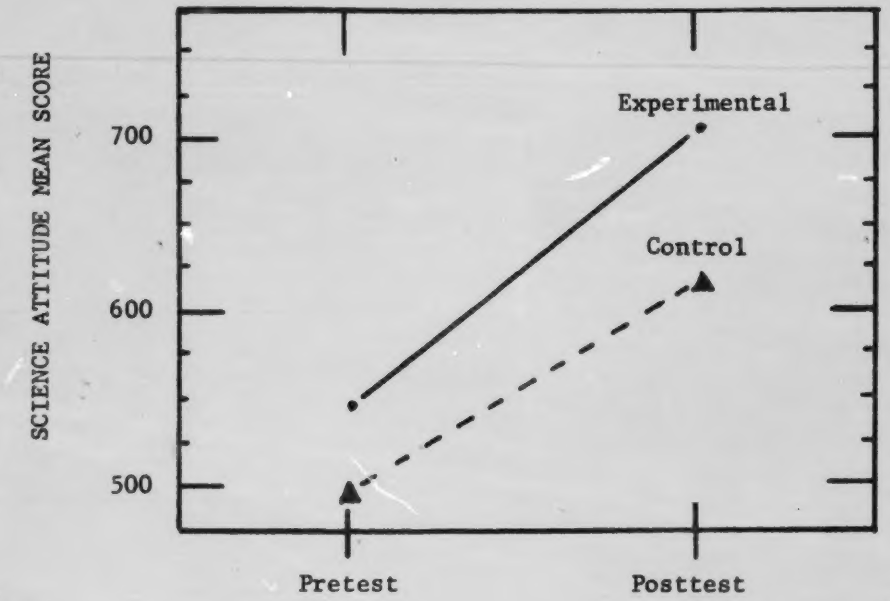


Figure 2
Science Attitude:
Graph of Cell Means

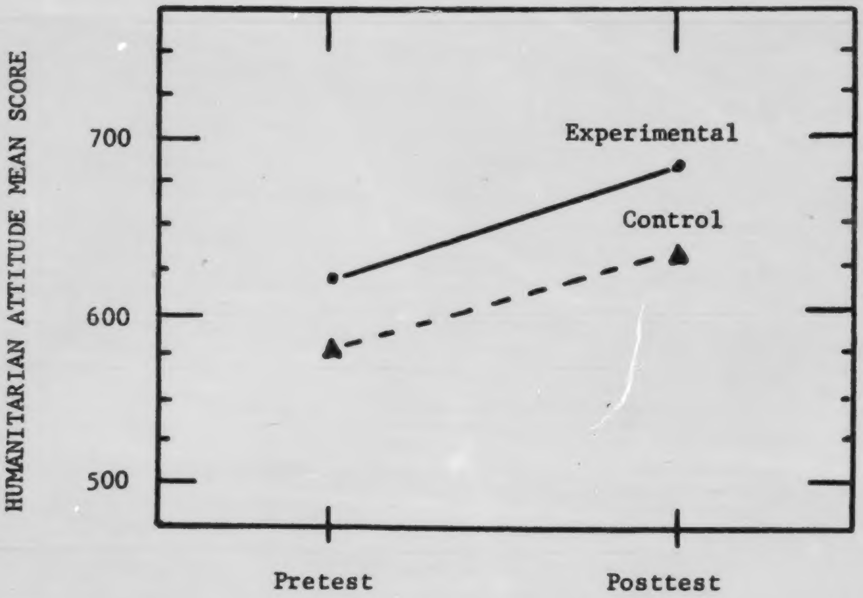


Figure 3
Humanitarian
Attitudes:
Graph of Cell Means

It is concluded that the continued association of a consistent staff personnel who concerned themselves with the students as individuals as well as the quality of the academics of science teaching can measurably improve students' intellectual and humanistic attitudes towards science and science teaching.

Piagetian-styled tasks

Pretesting was conducted in April of 1973. Students were administered the battery of Piagetian-style tasks in individual interviews of approximately 30 minutes each. Posttesting was conducted in a similar fashion in April of 1974. The interviews were conducted by two trained examiners who had no knowledge of which students were members of the experimental or control groups. Students were assigned to the examiners at random times during the course of the interviews. Each subject was interviewed by the same examiner during the pretest and posttest.

The two groups consisted of students who during their freshmen year were selected from a group of approximately 300 students initially enrolled in Biology 205, Biology for Elementary School Teachers. Pretests were administered at the end of the second semester of the subject's freshmen year. At that time the experimental group of 20 students (19 females, 1 male) ranged in age from 18.5 years to 19.7 years, mean age of 19.0 years, and the control group of 17 students (17 females, 0 males) ranged in age from 18.5 years to 19.5 years, mean age of 19.1 years.

Experimental and Control Group Comparison

Table 1 shows the results of the classification of experimental and control group subjects into substages of intellectual development for pretests and posttests. In the experimental group, 7 of the 20 subjects gained two substages from pre- to posttesting (post-concrete operational to middle formal operational) and 10 participants each gained one substage. One experimental subject showed no change from pre- to posttesting, while two showed a regression of one substage (early formal operational to post-concrete operational). Four of the control group subjects showed a pre-to posttest gain of two substages, while one showed a gain of one substage. Of the remaining 12 students tested, 9 showed no change and three showed a loss of one substage.

A comparison of the mean pretest and posttest levels shows that the control group's pretest mean level (4.65) was higher than that of the experimental group (4.20). Applying the Mann-Whitney U Test, this difference was found not significant at the .05 level (U = 135.5, p = .27). The posttest mean levels of 5.30 for the experimental group and 5.06 for the control group were also not significantly different at the .05 level (U = 142.0, p = .19). The mean gain in level by the experimental group (1.10), however, was significantly higher than that of the control group (.35) at the .01 level (U = 99.5, p = .01).

TABLE 1

	Experimental (N = 20)		Control (N = 17)	
Substage	Pretest	Posttest	Pretest	Posttest
Early concrete operational	0	0	0	0
Middle concrete operational	1	0	0	0
Late concrete operational	4	0	0	1
Post-concrete operational	7	4	10	5
Early formal operational	7	7	4	5
Middle formal operational	0	8	2	5
Late formal operational	1	1	1	1

Since the control group mean pretest score was higher than that of the experimental group, the possibility existed that the smaller gains made by the control group could have been due to a ceiling effect. To check this possibility an analysis of covariance removing effects of the pretest was carried out. The obtained F-ratio of 3.33 (d.f. = 1,35) failed to reach significance at the .05 level.

The sample used in the study was a small one and all of the subjects were preservice elementary teachers. It is therefore not possible to generalize from these results. However, the fact that gains in level of intellectual functioning made by the experimental group involved in the UPSTEP project were significantly greater than the control group's gains suggests that curricular materials which confront students with concrete materials and problems can promote the development of formal thinking abilities.

PURDUE UNIVERSITY

Freshman Year (1972-1973) UPSTEP PROJECT

Topics Covered in Education 323 - The Teaching of Science in the Elementary School, 1st Semester, first year

TOPICS:

- What is science?
- The job of teaching science in the elementary school.
  - Drastic changes expected
  - Should education reflect the spirit of science
- Overview of science in the elementary school
- Overview of science teaching in the elementary school as purported by the three major, national curriculum, elementary school programs.
  - Science - A Process Approach (S-APA)
  - Science Curriculum Improvement Study (SCIS)
  - Elementary Science Study (ESS)
- Instruction in the basic skills of science (S-APA)
  - Observation
    - Using the five senses
    - Static observations vs dynamic observations
    - Indirect observations vs direct observations
      - Mystery boxes
    - Inferring vs observing
- Classification
  - Similarities and Differences (Attribute Games)
  - Position and Motion
    - Number line
    - Grid coordinates
    - 3-dimensional space
    - Polar coordinates
    - Longitude and latitude
- Measurement
  - Metric system
  - Precision and accuracy
  - Pressure and area
    - Length, width and height
    - Volume
    - Surface area
    - Weight
    - Mass
    - Density
    - Pressure
  - Equal arm balance
  - Normal variations
- Inferring/Predicting
  - Graphing
- Space/Time relations
- Formulating hypothesis
- Controlling variables
- Interpreting data
- Operational definitions
- Formulating models

- Problem solving and inquiry approach to learning
    - An inquiry model
        - Exploration
        - Invention
        - Discovery
- Problem solving situations via an inquiry approach
    - Surface, tension, cohesion, and adhesion
    - Why does a burning candle go out?
    - The glass rod experiment
    - The baggie garden experiment
    - Mealworms
    - Tangrams
    - Inference boards
    - The Cartesian diver
- Micro Teaching involvement
- Questioning and Listening
- Writing performance objectives
- Evaluation in the elementary school
- Construction of science materials
    - Terrariums
    - Electric boards
    - Weather apparatus, etc.
- Science Marathon day
    - Identification of basic tools for "sciencing"
    - Making a collection tank
    - Soldering
    - Bending and cutting glass
    - Counting calories
    - Parallel and series electrical hookups
    - Magnetism
    - Drilling and sawing wood
    - Lighting a propane tank, etc.
- Safety in science teaching
- How to survive a field trip
- Field trip day . . . Mini-course festival (Lebanon, IN)

Topics Covered in Biology 206N - 2nd Semester, first year

TOPICS:

- Populations
    - constants and graphing
    - using the compound microscope
    - scientific notations
    - hemacytometer
    - dilution
    - yeast experiment
    - observations of paramecia
    - competition in paramecia
    - daphnia - hydra
    - density

Sophmore Year (1973-1974)

Topics Covered in Physics 210A - 1st Semester, second year

The course begins with selected portions of College Introductory Physical Science, Prentice-Hall, Inc., 1969 and continues with selected portions of the Project Physics Course, Holt, Rinehart and Winston, 1970.

TOPICS:

- Astronomy Part I
    - simple observations of the sun, moon, and stars
- Measuring
    - linear measurements
    - linear measurements using metric units
    - making comparisons using a balance
    - ordering plane figures by area
    - estimation and comparisons using the metric system
    - measuring volumes

- Astronomy Part II
    - motion of the earth in relation to the sun, moon, and stars
- Density

- Astronomy Part III
    - a model of the celestial system
- A model for the composition of matter
    - thermal expansion of solids, liquids, and gases
- Solutions
    - solubility
- Decomposition and synthesis of water electrolysis
- Electricity
    - Battery and Bulbs

Topics Covered in Physics 211A - 2nd Semester, second year

TOPICS:

- Compounds and mixtures
- Building and remodeling
    - Laws of definite and multiple proportions
- Motion
    - Position, change in position, instant of time, and interval of time
    - Stroboscopic photography of moving objects
- Velocity
    - Average velocity
    - Instantaneous velocity
    - Acceleration
- Actions, inactions, and reactions
- Concepts, models, and theories are induced from observations that the students themselves can encompass, rather than from obscure a priori dicta.

Junior Year (1974-1975)

Topics Covered in Biology 205N - 1st Semester, third year

TOPICS:

Piaget testing techniques promoted in preparation for testing of elementary school children
Piagetian testing kits distributed and testing assignments made.

ECOSYSTEM

Group aquarium-terrarium systems assembled (8)

Topics covered related to the aquarium-terrarium ecosystem:
- Introduction at the appropriate time into the system: Plants, brine shrimp, isopods, frogs, polywogs, guppies, chameleon and mealworms
- Decomposition
- Plant growth
- Light and temperature
- Interrelationship between plants and animals
- Food chains
- Bromo-Thymol Blue experiment
  - Interrelationship of snails, plants carbon dioxide, and oxygen
  - Scientific American Reprint readings related to ecosystems
    - Nitrogen Cycle
    - Carbon Cycle
    - Oxygen Cycle
    - Water Cycle
    - Energy Cycle of the Biosphere
    - Energy Cycle of the Earth
    - Biosphere
- Carbon dioxide and oxygen cycle
- Nitrogen cycle

Ecosystem - a way of looking at the environment (as a model).

Function of respiration and photosynthesis in relation to energy
Producer, primary consumers, secondary consumers
Pyramid of energy
Habitat and niche
The concept of steps up from individual organisms to biome
The effect of man on his environment
Pesticides and herbicides and how they effect the environment

Fresh water pond succession

Human reproduction (audio-tutorial sex education unit)

Tree identification "Fifty Trees in Indiana"

Plus accompanying appropriate teaching methodology to translate these topics into viable elementary school lessons

Topics Covered in Biology 395N - 2nd Semester, third year

TOPICS:

- Rock and mineral unit
  - Identification of basic rock forming minerals (9)
  - Rock and mineral puzzle
  - Mineral puzzle
  - Construction of a basic rock-forming mineral calculator
- Weathering of rock
- Metamorphic vs igneous vs sedimentary rock
- Science - A Process Approach (S-APA) exercise in classifying minerals
- Sedimentation experiment
- Making a rock (cementation process)

Elementary Science Study (ESS) lesson planning in preparation for a three week teaching stint with children in the local public school by the UPSTEP participants.

Drug unit

Marijuana, drug education minicourse, alcoholism sources of information, annotated bibliography, examination of exemplar sex education programs in the elementary school.

Woodland field experience

- Topics covered in woodland field trips
  - adaptation
  - organisms
  - soil examination
    - soil samples taken and examined in the laboratory
  - agar plate experiment
    - soil and leaf agar innoculations made
  - soil samples at various depths in various locations taken and examined; samples were dried out and various life forms contained within and driven off examined.
  - soil sample dilution experiment

The Stream
- Observations and collection of stream plants and organisms
- Comparisons of samples from various collection sites

Wildflower unit

Marsh unit
- Observation of a marsh environment
- Detailed study of the red-winged blackbird

Plus accompanying appropriate teaching methodology to translate these topics into viable elementary school lessons

EXEMPLAR UPSTEP PROJECT UNITS

F. Yeast Experiment

1. Objectives:

Upon completion of this activity the student will be able to:

a. inoculate a culture medium with yeast cells and count the number of cells in samples of the culture over a 10-day period.
b. express the number of cells counted with the hemacytometer in terms of cells/ml.
c. construct an appropriate graph of his data.
d. accurately interpret his results.

2. Procedure:

Inoculate 125 ml of sterile water with 1 gram of dry yeast. Shake the flask to suspend the cells. Transfer 1 ml of the suspension to 99 ml of water. Shake the second dilution. Then transfer 1 ml of this suspension to each of 2 flasks of 49 ml of culture medium. Incubate one flask at 30°C and the other at 20°C.

Count the number of cells in a sample of the second dilution, and determine the number of yeast cells added to the 49 ml of culture medium. Convert this concentration to number of cells per ml in the 50 ml yeast cultures.

For a period of 10 days, count and record the number of yeast cells in each of the two cultures every day.

3. Evaluation:

Present your results in the form of (an) appropriate graph(s) and write a short paper discussing the observations you have made. Include in your discussion any of the following points or questions which may be applicable to your results.

a. Experimental error.
b. Any differences in the rate of growth of a population.
c. Any differences between the two cultures (i.e., 20°C and 30°C).
d. If any differences were observed, how might they be explained?
e. How do your results compare to the Awful Alfred model?
f. Use your results to formulate a model of population growth.
g. Can you generalize from your model to other populations? What would you have to do to test the power of your model in making predictions?
h. Can an incorrect model be a "good" model?

Unit I - POPULATIONS

4. References:

a. Anderson, R. D., Devito, A., Dyrli, O.E., Kellog, M., Kochendorfer, L., and Wiegand, J. 1970. Developing Children's Thinking Through Science. Prentice-Hall, Inc. Englewood Cliffs, New Jersey. p. 61-67.

b. Minnesota Environmental Sciences Foundation, Inc. 1972. The Rise and Fall of a Yeast Community. National Wildlife Federation. Washington, D.C. 20pp.

G. Observations of Paramecia

1. Objectives:

Upon completion of this activity the student will be able to:

- a. estimate the length and width of the organisms in a Paramecia culture.
- b. estimate the rate of swimming of the organisms in a Paramecia culture.
- c. describe the shape of the organisms in a Paramecia culture.
- d. describe structures or behaviors which will help to identify these organisms.

2. Procedure:

Place a few drops of the Paramecia culture on a watch glass. Using a hand lens and a light source below the watch glass, examine the culture.

Next, make a wet mount from the culture and examine it with a compound microscope. When appropriate, a drop of Protoslo added to your slide will slow the Paramecia and make it easier to observe them. What is the effect of adding a drop of vinegar to a slide containing Paramecia?

3. Evaluation:

When you have recorded enough observations to satisfy the objectives consult with an instructor.

H. Competition in Paramecia

1. Objectives:

Upon completion of this activity the student will be able to:

- a. count and classify the organisms in a six day culture of Paramecia.
- b. construct an appropriate graph(s) showing the relationships among the counts from the six day culture and data given from a two and a twelve day culture.
- c. accurately interpret the results obtained from a two, six, and twelve day culture of Paramecia.
- d. construct and interpret a graph of data given from another population of Paramecia.

2. Procedure:

Obtain five microscope slides and cover glasses. Vigorously shake the tube of six day Paramecia culture and as quickly as possible remove a sample with a pipette dropper. Make a wet mount using one drop of culture and one drop of Protoslo (or vinegar). Repeat this procedure until you have five wet mounts of the six day culture. Use your microscope to observe, classify and count the organisms in each of the five slides. If the culture is too concentrated for convenient counting it may be necessary to make a serial dilution before classifying and counting.

3. Evaluation:

- a. combine your data from the six day culture with data given from a two and a twelve day culture. Graph the data and be able to interpret these results.
- b. given the data from a Paramecia population experiment of Gause, graph the data and interpret the results.
- c. contrast the results of the two sets of data. When you are satisfied with your ability to discuss these results, consult with an instructor.

4. Reference:

Gause, F. F., The Struggle For Existence. Hafner Publishing Company, New York, 1964. 163 pp.

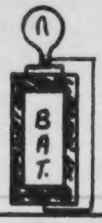
Unit 7
Checkout

FORM A

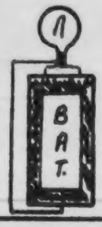
Physics 210A
1st Semester, second year

1. In which of the configurations below will the bulb not light? In each case, explain why it will not light.

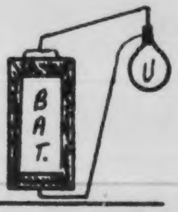
(a)



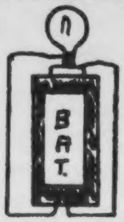
(b)



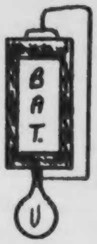
(c)



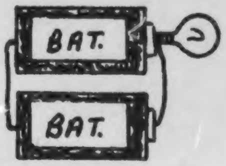
(d)



(e)



(f)



2. From your observations of the configurations that make the bulb(s) light, can you show any evidence for the direction of "flow" in a circuit? Explain why or why not.

3. Three identical light bulbs are connected as shown in the diagrams below.

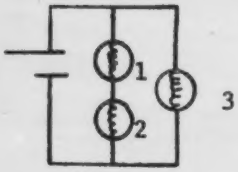


Fig. I

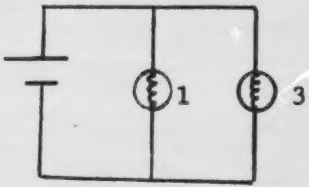


Fig. II

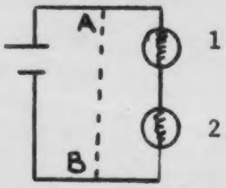


Fig. III

a) What will happen to each of the bulbs when Bulb No. 1 is unscrewed from the socket (see Figure I). Explain.

b) What will happen to each bulb in Figure II when Bulb No. 3 is unscrewed? Explain.

c) In Figure III, a length of nichrome wire is placed between points A and B (see dashed line). What will happen to the brightness (if anything) to the bulbs? Explain.

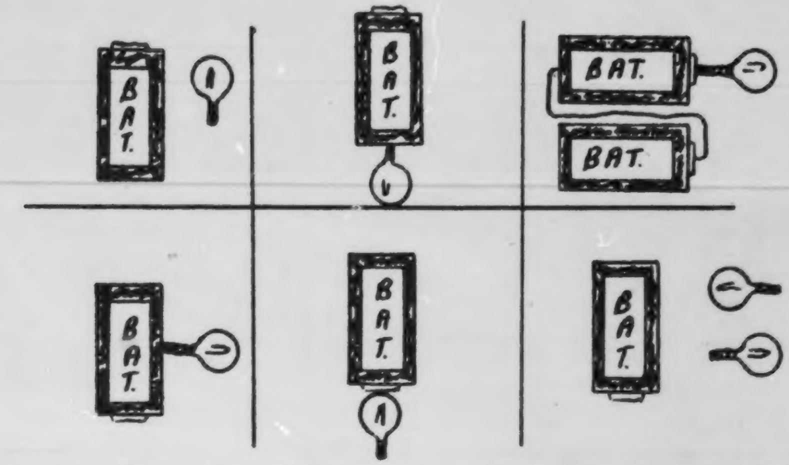
d) How would your answer to part "c" differ if the nichrome wire were replaced by copper wire? Explain.

Unit 7
Checkout

FORM B

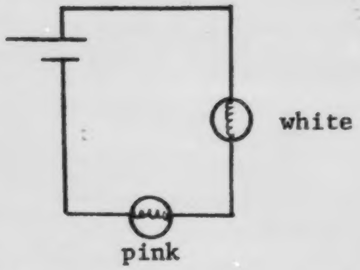
Physics 210A
1st Semester, second year

1. Draw the wires that will make each bulb light.

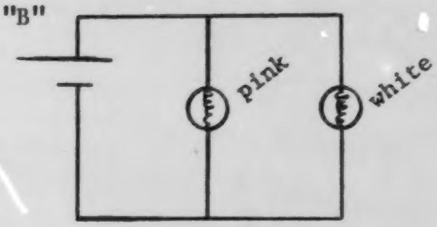


2. a) Circuit "A" below represents a configuration that results in the pink bulb glowing but not the white bulb. How can you explain this?

"A"



"B"



b) Suppose the circuit is now changed to look like circuit "B" above. Explain what you might see happening with regard to whether one or both bulbs light and the relative brightness.

3. Is there any way that you can tell from your observations of the various battery-and-bulb configurations which direction the "flow of electricity" takes? Explain.

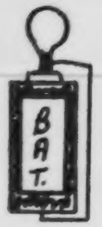
Unit 7
Checkout

FORM C

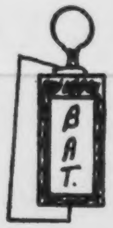
Physics 210A
1st Semester, second year

1. In which of the configurations below will each bulb light? Explain why the others will not light.

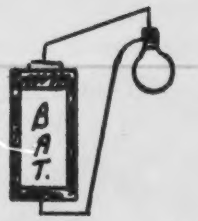
(a)



(b)



(c)



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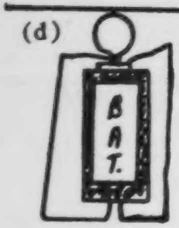

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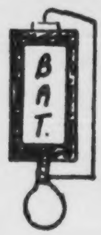
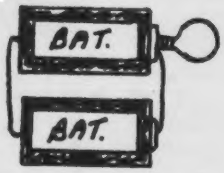


(f)



2. From your investigations of the various configurations of batteries and bulbs, what factors do you believe influence the intensity or strength of what is "flowing" through the circuit?

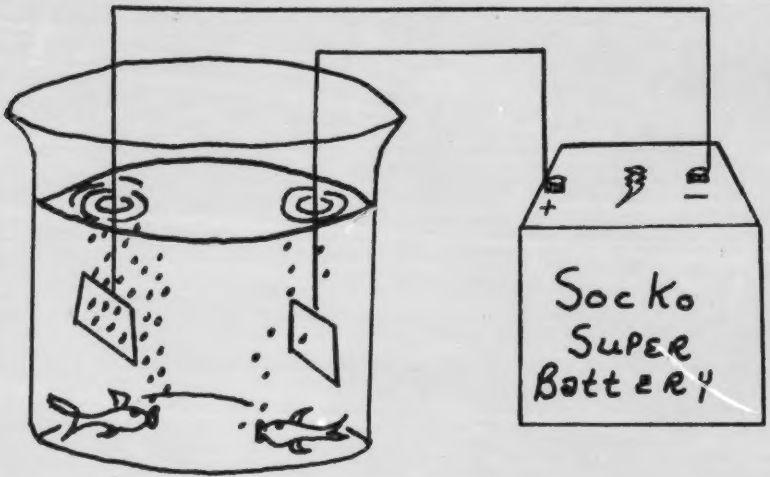
3. As you may have observed, when a light is turned off (or burned out) in a house, the other lights are not visibly affected. Based on your observations of the different types of arrangements that are possible with the batteries and bulbs, explain how this is possible. Use diagrams to support your explanations.

UNIT 5 - PART 1

DECOMPOSITION AND SYNTHESIS OF WATER - A "TERMINAL" ACTIVITY

Physics 210A
1st Semester, second year

INTRODUCTION



Water, Water everywhere! It goes without saying that water is a very common and recognizable substance in our environment. Moreover, it seems that no matter what we do to it - boil it, freeze it, mix it with other substances - it still remains water. The early Greeks even thought of it as the primary substance from which all other substances were derived. With the invention of the electric cell by Alessandro Volta in 1800, studies in the newly-discovered area of "electrochemistry" showed that water could quite easily be decomposed into more basic substances whose properties had no resemblance to the properties of water. In this Unit we will examine this process of electrolysis (and the opposite process called synthesis) and make use of the insights gained in the examination of these phenomena to begin formulating some initial concepts concerning electricity.

OBJECTIVES

After completion of the study of this Unit, you should be able to meet the following objectives:

1. Describe in your own words the basic regularity in Nature which is illustrated by the specific experience acquired in Experiment 6.2 and illustrated further by the experiments described in Section 6.3.

2. In the light of the sequence of experiments you will have performed with batteries, wires, bulbs, etc., give, in your own words, clear operational definitions of the concepts: "circuit," "electric current," "conductor and non-conductor."

3. Be able to predict what will happen (lighting or not lighting of bulbs, relative brightness, etc.) of various circuits that might be proposed to you or that you yourself will invent.

4. Out of your accumulation of experience since the beginning of this course (not confined to this Unit), give several examples of concepts that we have invented; show how concrete experience led to the formation and definition of the concept; and show how the concept has given us a deeper insight into some aspect, orderliness, or relationship in Nature than we had prior to formation of the concept. Then give an illustration of what we mean by a "model" in scientific thought. (Note that a "model" utilizes a number of concepts and organizes them into a way of visualizing a process or a systematic behavior behind phenomena that we observe.)

ACTIVITIES

I. a) Do Experiment 6.2 and read Section 6.3. While you are performing Experiment 6.2, estimate the volumes of gas that you are collecting (very round numbers will do - - compare the test tube volumes with those of graduated cylinders) and, referring to the density data in Table 3.2, calculate the total mass of gas you are collecting and the total mass of liquid water that must be "used up" in order to form the amount of gas you collect. What is the volume of the water "used up"? How does this volume compare with the volume of water initially in the test tube? State the point of this calculation and result in your own words.

b) Do Problems 3 (replace the term "acid" in this problem by "sodium carbonate" - the latter being what you added to the water in your own experiment), 4, 6, 10. Read Problem 9; if you can show that you have already done a problem of this type, indicate the relevant work and proceed to the next assignment. If you have not worked out a problem essentially similar to 9, work out Problem 9 and discuss the conclusions to be drawn from it.

II. After you have completed assignments (a) and (b) above, proceed with the activities on electricity as outlined in Part 2 of this Unit. Ask a staff member to help you get started. The staff will give you periodic guidance and instructions during this work.

SOME CURRENT IDEAS ABOUT ELECTRICITY

INTRODUCTION

In the elementary science curricula, some consideration of what is usually called "current electricity" plays a key role in one or more stages of development. In one of the curricula (ESS), it occupies an entire unit of observation and inquiry. We shall digress for a brief examination of some of the most basic qualitative aspects of the phenomena associated with current electricity. Our treatment of the material will cut across the content of the various elementary curricula and will not exactly follow any one of them. The emphasis will be on your own concept formation at an adult level and not on a specific presentation to children at some particular grade. However, you may expect to pick up numerous ideas during this investigation that should be helpful to you in presenting these concepts to children. It should be emphasized that these activities, while appropriate for elementary school students, are rich in conceptual ideas that can challenge the thinking of individuals at all age levels.

We give the name "electricity" and use the adjective "electrical" in connection with the effects produced by batteries such as those utilized in Exp. 6.2. (Our household "electrical" outlets, of course, produce exactly similar effects with considerably greater intensity.) Let us understand from the start that electricity is not some kind of substance or material - any more than ideas such as length, time, heat, or temperature refer to substances or materials.

The situation is perhaps best understood if we first turn back to re-examine the manner in which we use the familiar word "gravity." From our sensation of having to support an object to keep it from falling towards the earth and from our observation that unsupported objects always do fall freely, continually increasing in speed, we begin to visualize the earth as attracting all objects toward itself. (With deepening perception of the underlying order and connection among universal physical phenomena, we subsequently realize that all objects attract each other in exactly the same way as the earth seems to attract us and all objects.) We use the word "gravity" as a name for this mysterious effect, an effect that we are not able to "explain" or describe in terms of some process or action. The sophisticated name thus serves not as an explanation but as a way of concealing our ignorance concerning this very familiar effect.

Although we have very extensive knowledge of how gravity regulates and controls a huge array of universal physical phenomena, we have no idea at all of what gravity "is." The situation with respect to electricity is very similar. Because of specific differences in context and character of relevant physical phenomena, we recognize that "gravity" and "electricity" are two entirely different effects. Just as we know a very great deal about the workings of gravity, so we also know a very great deal about the workings of electricity, but we still have no idea of what electricity "is." In order to handle some of these ideas in a correct and sound way with children, it is absolutely essential that you understand aspects such as those referred to in the preceding comments. There are many instances in which it is at least as important to understand what is not known about a particular situation as to understand what is known.

OBJECTIVES

1. In the light of the sequence of experiments you will have performed with batteries, wires, bulbs, etc., give, in your own words, clear operational definitions of the concepts: "circuit", "electric current", "conductor and non-conductor".

2. Be able to predict what will happen (lighting or not lighting of bulbs, relative brightness, etc.) of various circuits that might be proposed to you or that you yourself will invent.

3. Out of your accumulation of experience since the beginning of this course (not confined to this Unit), give several examples of concepts that we have invented; show how concrete experience led to the formation and definition of the concept; and show how the concept has given us a deeper insight into some aspect, orderliness, or relationship in Nature than we had prior to formation of the concept. Then give an illustration of what we mean by a "model" in scientific thought. (Note that a "model" utilizes a number of concepts and organizes them into a way of visualizing a process or a systematic behavior behind phenomena that we observe.)

ACTIVITIES

I. The sequence of learning involved in this study is designed to enable you to begin formulating some basic ideas about electricity. It is essential that you keep a detailed notebook record of the lines of investigation suggested below.

   A. Start in with only the following equipment: one battery, one flashlight bulb and one length of wire.

1. Proceed to hold these items together in such a way as to get the bulb lighted. Keep a notebook record of every single arrangement or configuration that you try. Do this immediately as you try it. Do not just whip through a great many configurations until you get the bulb lighted; that is not the point of the line of inquiry.

2. When you have found all the configurations that light the bulb, separate your diagrams, classifying in one group all those that do not light the bulb and in the other group all the ones that do.

   (If you ever do have occasion to go through this limited exercise with children, note that at this point you are engaged in a process of classification. The process now deals with ideas more abstract than classification by properties such as color, shape, texture, size, number of holes, etc. that the children go through very early in the elementary science program, but it is nevertheless classification and has its roots directly in the earlier, simpler experiences.)

3. Describe clearly in your own words what those configurations that do light the bulb have in common with each other and how they differ from the configurations that do not light the bulb.

4. Starting with one of the configurations that lights the bulb, interpose in this configuration as wide a variety of materials (paper, coins, fingers, pencils, keys, glass, etc. etc.) as you can reasonably find around your tables and in the laboratory. Again classify these materials by their behavior in this context. How would you describe the pattern that emerges?

B. After performing the above investigations, build a socket of your own, following the procedure outlined on one of the attached pages. Now that you have a convenient "holder" for the bulb, you can use it to investigate the construction of a standard ceramic socket.

1. Obtain a standard socket but do not screw a bulb into the socket. Building upon the preceding investigations, use the battery and a bulb in the socket you built as a logical test device to analyze how the socket is constructed. (i.e. what part is connected to what? Are the two clips connected to each other? If not, what is each clip connected to? What role do different kinds of materials play in its construction?) As part of your notebook record describe your examination and conclusions in your own words.

2. Now relate the above findings to the construction of your own socket. What are the corresponding parts? What part is connected to what? What is the role of the non-conducting parts, if any?

3. After having analyzed the construction and nature of the socket, you should start using the one you built as a convenient mounting for the bulb.

4. It may be helpful at this time to have a closer look at the bulb. Examine an available broken bulb. Are there any non-conducting parts in the construction of a bulb? If so, what is their purpose? i.e. what would happen if the non-conducting parts were not present? (You can test this out for yourself.)

C. Build a switch of your own following the procedure outlined on one of the attached pages.

1. Obtain more wires and investigate the nature of your switch in exactly the same way you investigated the construction and nature of the socket. Obtain a standard ceramic switch and investigate how its construction is related to the one you built.

2. Investigate how the switch is used to turn the bulb on and off. Keep a careful notebook record of the configurations you use by drawing diagrams in all cases. (Consult a staff member for advice as to convenient and widely-used shorthand symbols for the various elements that make up a diagram - elements such as battery, wires, bulb, switch, etc.)

3. Explain in your own words how the function of the switch is related to the basic ideas you established in Part A above.

D. Build more sockets, obtain more bulbs and wires, and go on to investigate the behavior of systems in which you light more than one bulb with just one battery.

1. How many arrangements (basically different from each other) can you discover? What are the essential differences between them?

2. What relationships can you discern between these arrangements and various aspects that you encounter in household situations?

E. Investigate the behavior of systems in which you light one bulb with two batteries.

1. How many arrangements (basically different from each other) can you discover? What are the essential differences between them?

2. If you left one bulb connected to each of the different arrangements of two batteries, with which arrangement do you think the batteries would last the longest before they ran down?

F. Throughout this sequence of observation, investigation, and experience, you can be evolving a "model" or mental picture of some sort of "flow" in the systems you are manipulating. A model of this sort does not spring up full blown and complete in all aspects and details from the very first steps. It evolves slowly from initial, crude, undetailed, incomplete notions, acquiring more and more refinement and detail as new experiences are added to the earlier ones. (We cannot hope to attain a rigorously detailed and complete picture out of the very limited sequence we are following; we must be prepared to leave various significant aspects open and unsettled.)

As you accumulate and continually review your observations and experiences, including the electrolysis experiment in 6.2, consider the following questions:

1. What experiences add together to suggest a model of an intangible flow of some sort in the systems under consideration?

2. Is it possible to deduce a direction of such flow from any of the situations dealt with?

3. Can you seize on any observable effects as possible indicators of some sort of "intensity" of the flow?

4. Is there any evidence of decrease in intensity in going from one side of the system to the other? i.e. Is there any indication that whatever may be flowing is disappearing or being "used up"? If flow is not being used up, then how could you verbalize in a simple way (without using technical terms you don't know the meaning of) about what is being used up?

5. What hints do you discern in your own observation that fixed and deeply related amounts of material (hydrogen and oxygen) are liberated at the two sides of the system in the electrolysis experiment and from the fact that, when a battery runs down, chemical changes take place throughout the entire body of the battery, not just at one side?

6. What inferences about factors controlling the flow can be drawn from the investigation of part (D)? Is the intensity or the amount of flow through each bulb the same for the different arrangements you investigated?

   While considering these various aspects of the flow model, sound out and exchange ideas with other students and members of the staff.

G. The following investigations may help to confirm or refute your ideas about the flow model and some of the questions raised in part F in this connection:

   1. The wires you have been using in your investigations are made of copper (or tin-coated copper). Is there a difference behavior of systems when the wires are made of different kinds of materials? (Note that the same question arose when you were out investigating the thermal expansion of tubes.)

   2. Investigate the behavior of systems when you insert a length of nichrome wire.
      a) What happens when you change the length of the nichrome wire?
      b) What are the observable differences, if any, between systems with nichrome wire and systems with copper wire?
      c) What inferences about factors controlling the amount of flow can you draw from these observations?
      d) Is the wire which glows in a bulb more like the copper wire or more like the nichrome wire?

3. We have several "wet cells" available in the lab. These batteries have a lifetime of only a few minutes.

4. Investigate how long the battery lasts before it runs down when you use it to light different arrangements of bulbs.

5. On the basis of your flow model make a prediction of the results before you do the experiment. Consult a staff member before you start.

II. When you have completed this Unit to your satisfaction, obtain a Unit Checkout and test your understanding of the various concepts presented.

HOW TO MAKE A SIMPLE TAP SWITCH

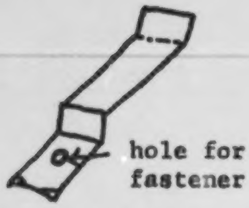


Fig. 1

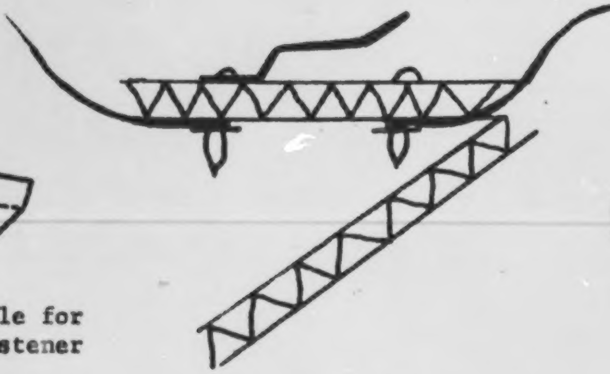


Fig. 2

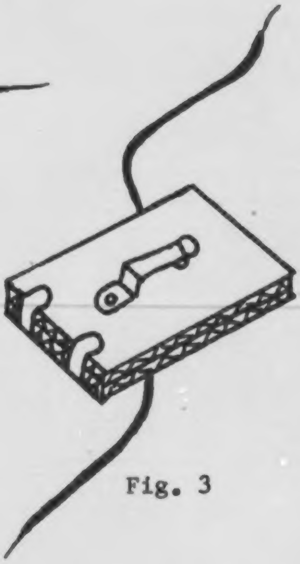


Fig. 3

MATERIALS:

A piece of corrugated cardboard 3" by 8"; two paper fasteners; two paper fastener washers; two connecting wires each about 6" long; a strip of metal from a "tin" can (ditto fluid cans work well) 2" by 3/4" (file the rough edges); and some masking tape.

PROCEDURE:

Bend the "tin" can strip as shown in Fig. 1. Be sure to crimp the corners where the strip comes in contact with the cardboard (if you want to keep the switch from pivoting - another version is possible). Pound the fastener hole with a nail. Be sure to scrape off any paint where electrical contact is made. Why?

Make a knife cut halfway through the cardboard so that the cardboard is divided (but still held together) into two 3" by 4" halves.

Poke the paper fasteners through the cardboard as shown in Fig. 2 and wrap one end of a connecting wire around each paper fastener. Add the washers and, pressing them firmly against the wires and cardboard, bend over the ends of the fasteners. Tape the two halves of cardboard together as shown in Fig. 3 and the switch is completed.

Note: There are many other uses for this general form of switch. Could you design one for a different purpose?

HOW TO MAKE A SIMPLE LAMP RECEPTACLE

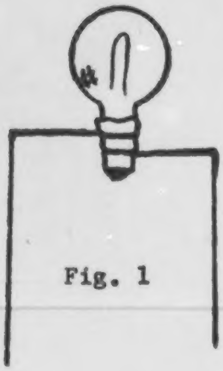


Fig. 1

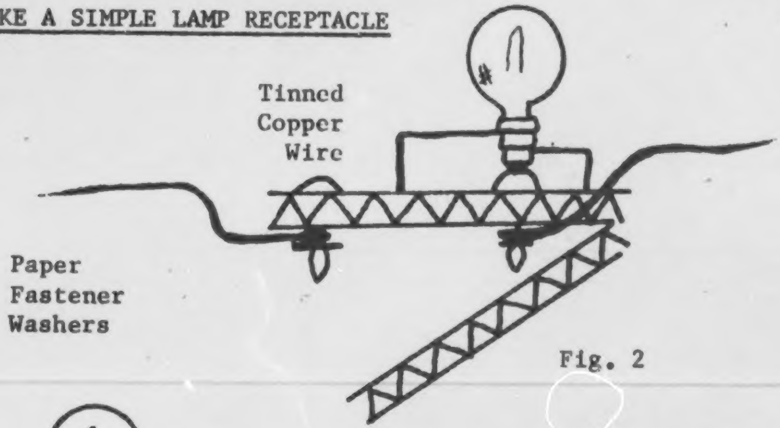


Fig. 2

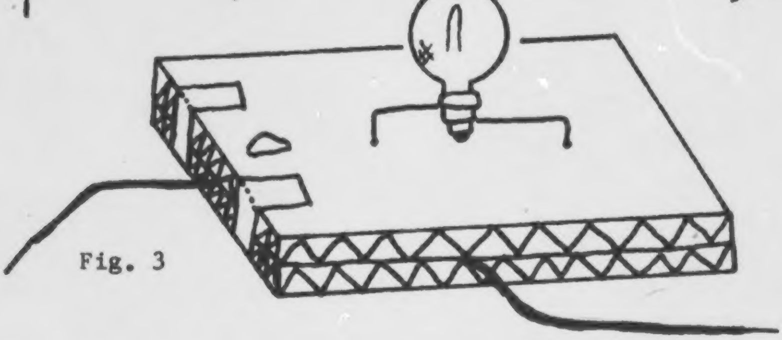


Fig. 3

MATERIALS:

A piece of corrugated cardboard approximately 3" by 8"; two paper fasteners; two paper fastener washers; two connecting wires each about 6" long; an 8" piece of #18 wire (copper) uninsulated and preferably tinned for the lamp support; a threaded flashlight bulb; and some masking tape.

PROCEDURE:

Make a knife cut halfway through the cardboard so that the cardboard is divided but still held together into two 3" by 4" pieces. Poke holes through the cardboard with a nail and insert the paper fasteners. Wrap the ends of the connecting wires around the paper fasteners as shown in Fig. 2.

Wind the lamp support wire around the light bulb and shape it as shown in Fig. 1. Placing the tip of the lamp on the paper fastener head, mark where the lamp support wire ends should penetrate the cardboard and poke holes at these points. Insert the support wire and wrap one end around the outside paper fastener. Bend the other end over for support BUT DO NOT FASTEN IT TO THE CENTER FASTENER.

Add the paper fastener washers and, pressing the washers tightly against the wires and cardboard, bend over the paper fasteners. Be sure that the paper fasteners do not touch each other. Fasten the two pieces of cardboard together with masking tape and the lamp receptacle is complete.

Connect your socket with bulb screwed into the support wire to a battery and be sure the bulb lights. If it does not light, check all the precautionary measures mentioned above.

UNIT 7

ELEMENTARY SCIENCE REFERENCES

ESS

Batteries and Bulbs (4-6)
Batteries and Bulbs II (5-higher)

AAAS

Part E, Exercise a. -- Inferring Connection Patterns in Electric Circuits.
Part E, Exercise i. -- Electric Circuits and Their Parts
Part E, Exercise j. -- Conductors and Non-Conductors.

SCIS

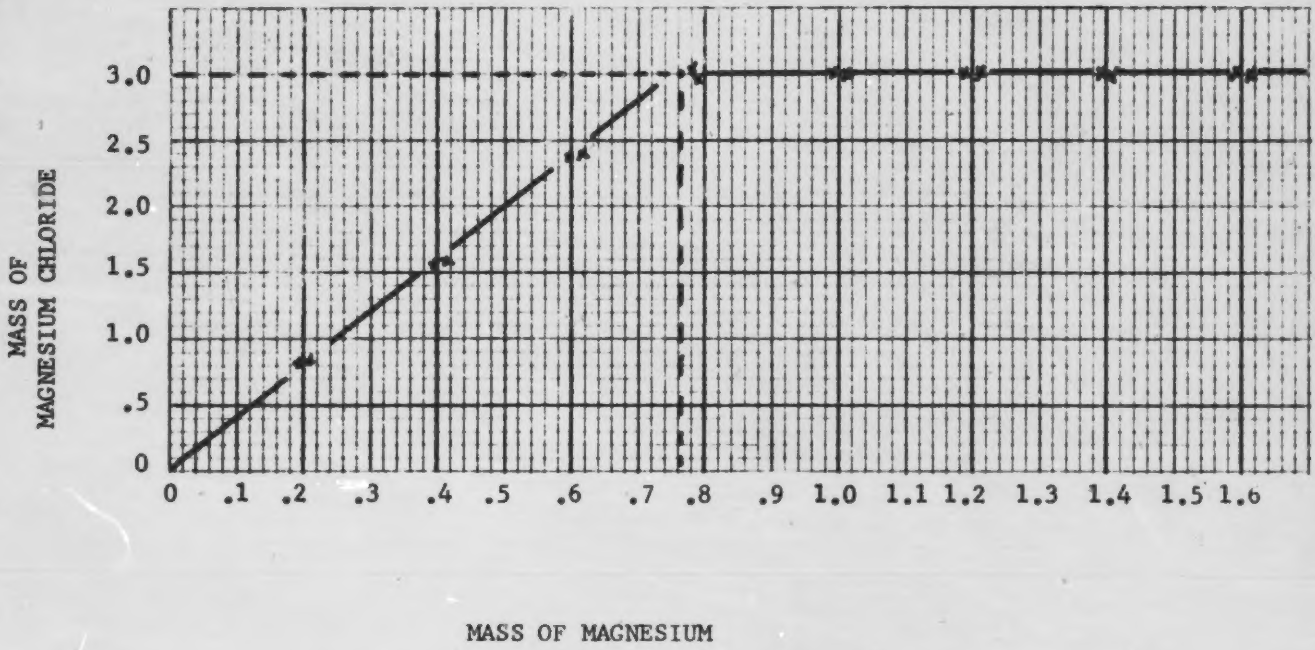
Interaction and Systems, Chapter 18 -- Electric Circuits
Interaction and Systems, Chapter 19 -- Objects That Can Close A Circuit
Interaction and Systems, Chapter 20 -- Electric Circuit Puzzles.
Subsystems and Variables, Chapter 1 -- Investigation Systems and Interactions.
Subsystems and Interactions, Chapter 5 -- Electric Circuit Puzzles
Models: Electric and Magnetic Interactions (Entire Unit).

Unit 5
Checkout

FORM A

Physics 211A
2nd Semester, second year

1. The graph below shows data points for experiments in which different amounts of magnesium were combined with a fixed amount of hydrochloric acid to yield magnesium chloride and hydrogen. In answering the questions below, please refer to this graph. Explain all answers.



a) Which region of the graph shows data points for experiments in which all of the magnesium was used up.

b) Which region shows data for experiments in which there was magnesium left over?

c) What is the ratio of the mass of magnesium chloride to the mass of magnesium that reacted?

d) How can we explain the fact that the ratio of the mass of magnesium chloride to the mass of magnesium that reacted with the acid is the same for all experiments?

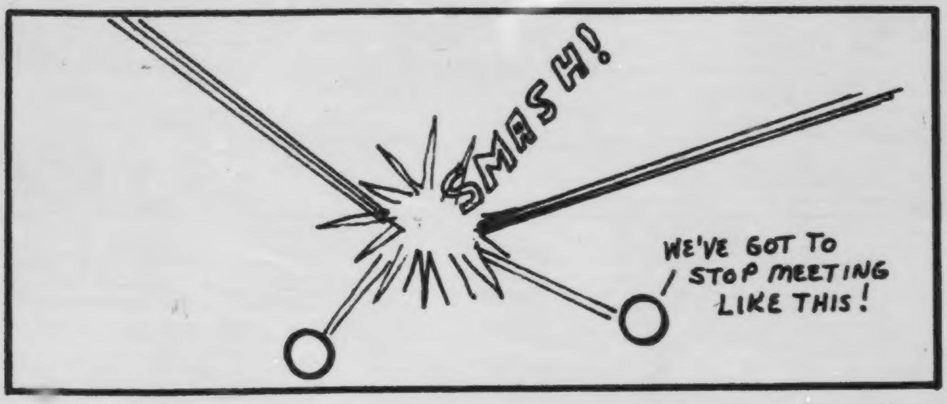
2. Consider the following experiment in which 4.0g of A is heated very strongly, resulting in a new substance B of mass 4.[illegible]g.

a) Could either A or B be an element? If so, which one(s)? If not, why not?

b) Could both A and B be elements? Why?

3. Do Problem 7, p. 183 in your text.

PUTTING ON THE PRESSURE
(Molecular Motion Can Really Be a Gas!)


SMASH!
WE'VE GOT TO STOP MEETING LIKE THIS!

INTRODUCTION

In the past several units we have experimented with materials that are both easily seen and readily handled. Indeed, our generalizations regarding motions of objects and the forces that govern these motions were a result of observations and inferences related to the behavior of such things as pucks and carts. Are the same rules readily transferable to the molecular realm? To investigate this we now turn to motion at the molecular level, utilizing some of the properties of gases that we inferred from earlier studies of the states of matter. We will attempt to learn whether the behavior of gases can be explained by a model that assumes molecules to be subject to the same laws of motion as macroscopic objects.

OBJECTIVES

Upon completion of this unit of study you should be able to meet the following objectives:

1. Define pressure in general and in particular describe how the pressure of a gas may be related to molecular motion.
2. Define temperature in terms of the molecular gas model.
3. Explain, using the molecular model, how separate gases mix together when placed in contact.
4. State in your own words how the pressure, volume, and temperature of a gas are related.

ACTIVITIES

I. For the most part, the activities of this Unit will consist of selected readings and experiments associated with Chapter 10 in the CIPS text with additional activities from the PPC Handbook.

A. Read CIPS, 10.1 to 10.5.

B. Do Experiment 29 (Part I) in the Project Physics Handbook, p.200.

C. Do Experiment 10.6, CIPS.

D. We have set up in the laboratory three or four gas-model machines of the type illustrated on p. 275 of your text. Experiment with these models by investigating the behavior that results from changing the number of spheres, the number of pistons, and the voltage to the motor. What role does each of these variables play in the model. Read Section 10.7, CIPS.

II. Upon completion of the activities in Part I above, and drawing upon your experiences from earlier units, especially Unit 10, you should begin to formulate answers to such questions as?

A. In the case of a gas, how would you visualize the behavior of the molecules? What do they do to each other on collisions? Describe in terms of visible collisions that you can arrange yourself among the pucks that can be made to slide around on the air table. How do they move between collisions? What happens when a molecule collides with a wall of the container? What is the effect on the molecule? On the wall? What would you feel if your hand were sufficiently sensitive to detect a single colliding molecule? What do you see to be the overall effect of millions of millions of millions of collisions taking place over every bit of wall surface in the container? How might the effect change if the speeds of the molecules were increased? Decreased?

B. What might be the essential difference between a liquid and a gas, i.e., what kinds of actions or interactions might you appeal to for holding molecules together in the aggregation we call liquid (or solid, for that matter)? What would happen to the velocity of a fast molecule as it emerged through the liquid surface and proceeded to move further and further away from its originally close neighbors in liquid, escaping into the gaseous region where its neighbors are, on the average, very far apart? Do you see any analogy between the behavior of the molecule while it is still close to the liquid surface and the behavior of a ball thrown up in the air? Why does the molecule not come back "down" immediately? Might it get back into the liquid eventually? If so, by what process?

C. In the light of the concepts we have been developing and extending, thinking of interactions such as push, pull, attraction, etc, how would you try to account for the observed fact that solids are very hard to pull apart (or stretch) but are also very hard to compress (or squeeze together)?

An Aquarium - Terrarium System

A great deal of our work in this unit will center around the studies we shall make of organisms and their surroundings in an aquarium-terrarium system. The initial activity of these investigations involves setting up the system.

1. Materials:

A. For a group of 3

1. One aquarium tank with partition
2. One water sprinkler
3. One light source

B. For the class

1. Soil
2. Sand
3. Rocks
4. Assorted seeds
5. Anacharis (pond weed)
6. Algae culture
7. *Daphnia* culture
8. Guppies
9. "Mystery" snails
10. Pond snails
11. Tadpoles
12. Crickets
13. Chameleons
14. Frogs
15. Mealworms
16. *Drosophila*

I. Setting Up the System and Adding Plants.

A. Procedure:

1. Fill one side of the tank with soil to a depth of approximately 2½ inches. The soil surface need not be level, it may slope, or it may be terraced with rocks.
2. Select at least 4 different types of seeds from those supplied and plant as many of each type as your group regards as desirable. Be sure to note the type of seeds, the number of each type (except for small grass and clover seeds) and the positions of planting.
3. Water the soil after planting.
4. Place about 1 inch of washed sand in the other side of the tank. Fill with water to a depth of approximately 5 inches. If you use fresh tap water and not aged water, add 7 drops of "Aqua-D-Chlor" to dechlorinate the water.
5. Once the sand has settled in the tank, take 2 or 3 sprigs of Anacharis (pond weed) and plant them in the sand.
6. Add about 50 ml of the algae culture to the water in the aquarium.
7. Place the tank close to a light source so that both sides are provided with light.

8. Observe the system carefully throughout the length of the activity, ensure that the soil is adequately watered.
    (a) Did all your seeds germinate? If not, how can you explain why?
    (b) Are all places in your terrarium equally suitable for seed germination? Explain.
    (c) Is it possible to detect the presence of the algae in the aquarium? Explain.

II. Introducing Daphnia into the System

About a week after setting up the system add a given quantity of the Daphnia culture to the aquarium.

III. Adding other Animals to the System

1. About two weeks after adding the Daphnia and when the growing plants are well established, add the following animals to the system. You will be advised of the maximum number of each available to your group.

Guppies
"Mystery" snails
Pond snails
Tadpoles
Drosophila

Crickets
Chameleons
Mealworms
Frogs

2. Once the animals have been introduced observe the system carefully and record your observations. If possible, you should arrange for a member of the group to observe the system one or two times a day over the next three days. Observe long enough to answer the following questions.
    (a) Do any organisms move between the aquarium and the terrarium? If so, which ones.
    (b) What happens to the size of each population of organisms over the course of time?
    (c) Record the location of all organisms. Do they remain in one location or do they move about the whole system?
    (d) Describe how each type of animal gathers food, i.e., what does it eat and how does it get it?
    (e) What happens to dead organisms?

Questions on Readings

1) List all the organisms on earth that you believe exist by causing an imbalance of world ecosystems.

2) What problems appear to occur as a result of irrigation of agricultural lands? What is the alternative to irrigation?

3) What problems appear to occur as a result of the application of pesticides in agricultrual environments? What is the alternative to the use of pesticides?

4) From your reading you have seen that phosphorus may be a limiting resource because it does not recycle rapidly through the ecosphere. One could argue, then, that man could aid the process by releasing more phosphorus into the environment, yet in some places laws have been passed prohibiting the widespread release of phosphorus in the form of phosphate in detergents. How do you explain this apparent contradiction?

5) Recently, millions of chickens had to be destroyed because they had become contaminated with dieldrin, a powerful pesticide which is chemically similar to nerve gas. As dieldrin is absorbed into the sap of plants, it can be used as a spray to kill plant-sucking insects such as aphids.

Suppose that you make a living by growing lettuces. The law allows you to spray your crops with chemicals such as dieldrin to control damage by insects, up to but no later than six weeks prior to harvesting the lettuces. You comply with the law and find that your lettuces tend to become wilted and damaged due to insect attack a few days before harvesting. Consequently you cannot sell them for a good price. In contrast, other growers bring crops, undamaged lettuces to market and sell them for good prices, so you are developing a poor reputation in the market.

How do you explain the situation, and if it was real, what would you do?

6) During this unit, you have been introduced to some basic considerations about relationships between organisms and their environment. This introduction should help you to better understand the environmental problems that man is facing at the present time, and it should also help you realize that solutions are not simple or obvious.

As a teacher, you may take one or several courses of action with respect to teaching children about environmental responsibility. You may:

- ignore the problem altogether, especially if the children you teach are very young;
- attempt to indoctrinate them in your beliefs about the problem
- try to present all points of view on the problems;
- give them occasional warnings;
- or some other form of response.

What will you do, and why?

Decomposition

This activity represents one of a series of investigations we shall undertake to explore the relationships which exist among organisms and their surroundings. As this activity is of a relatively long-term nature, we will begin it now so that results will be available in a few weeks time.

1. Objectives:

   Upon completion of this investigation we should have obtained information about rates of decomposition and factors which affect decomposition of different kinds of organisms.

2. Materials:

   a. plants
   b. dead animals
   c. sterilized washed sand
   d. sterilized vials and caps
   e. soil
   f. antiseptic solution
   g. water
   h. light source
   i. heat sources

3. Procedures:

   a. Select a partner to work with.
   b. Use the materials listed above or any additional materials you may need or want to set up an experiment or a series of experiments which will attempt to answer the question:

      What factors affect the decomposition of dead organisms?

   c. As you set up your experiments, keep a record of what you have done and list any specific questions your experiments attempt to answer.
   d. During the next few weeks make regular observations and record them. Remember you have more than one sense.

INTERRELATIONSHIPS BETWEEN PLANTS AND ANIMALS

1. Introduction:

Our investigations into the interdependencies of populations of organisms living in the same general environment has led us to develop the concept of an ecosystem. We have discussed the flow of nutrients through an ecosystem, but there are other factors operating in an ecosystem which we should consider.

2. Objective:

In this activity we shall investigate some of the relationships that exist between plants and animals and their environment.

3. Materials and Equipment:

1. Screw top jars - 4 per group
2. Drinking straws
3. Medicine droppers
4. Molten paraffin wax
5. Paper towels
6. Brom-thymol blue solution (0.1%)
7. Dilute ammonium hydroxide solution
8. Mystery snails (2 per group)
9. Anacharis (2 nine inch lenghts per group)
10. Deionized water
11. 20 ml beaker (one per group)

4. Procedure:

(a) Select a partner to work with.

(b) Rinse a 20 ml beaker or some other small container with de-ionized water and then half-fill the beaker with de-ionized water. Add brom-thymol blue solution a few drops at a time until the water is visibly colored when viewed against a white background. Now carefully add some ammonium hydroxide solution, a drop at a time, until the water turns blue.

(c) Take a drinking straw and blow into the water in the beaker for about a minute.

(1) What happens to the color of the water?
(2) What is your breath adding to the water that may cause the change?

(3) May other chemicals also cause such a change when added to water colored blue with brom-thymol blue?

(d) Rinse 4 screw-top jars in de-ionized water and then half-fill each one with de-ionized water. In one jar place a "mystery" snail, in another place a length of Anacharis. Do not place any organisms in the fourth jar.

(e) Use brom-thymol blue solution and ammonium hydroxide solution to make the water in each jar blue and then fill each jar to the brim with de-ionized water. Screw tops down firmly, dry the jars and seal the tops by inverting them into molten paraffin wax.

(f) The jars should be placed on a window ledge where they are exposed to daylight for most of the day. They should be observed three times a day - early morning, midday and dusk - for a period of 4 or 5 days, and the color of the water in each jar noted on each occaseion.

5. Discussion:

(4) What is the purpose of the brom-thymol blue in these jars?

(5) Why have the jars been carefully sealed?

(6) Would it be correct to call each jar an "ecosystem"?

(7) What is the purpose of the fourth jar?

(8) What hypothesis or hypotheses will this experiment test?

(9) For each hypothesis mentioned in (8), write a prediction.

6. Results:

(10) Prepare a table of your results. If they differ from your predictions, attempt to explain why.

(11) Have your hypotheses been confirmed or not? Explain in each case.

(12) Is it possible to draw any conclusions
(i) from your own results?
(ii) from the class results?
Explain in each case.

PHASE II

PHASE II

The Purdue University Undergraduate Pre-Service Teacher Education Program (UPSTEP) commenced in the fall of 1972. Phase I covered the first three years of this project 1972-75. Phase II covered the last two years of the project 1975-78. Sixty three participants started in the project. Four years later thirty seven members of the original group graduated with baccalaureate degrees in elementary education.

Of the twenty six participants who did not complete the project, six participants disengaged themselves from the project at the freshman level for a variety of reasons ranging from social to scholarship problems. Nine students transferred to other universities for economic and/or social reasons. Three participants married, became mothers, and dropped out of the university. Eight participants changed majors. This probably was a consequence of the early component of the project wherein educational science methodology (1st semester, freshman level) and early and continued field experience with children (2nd semester, freshman level through the end of the sixth semester, junior level) was initiated. It is thought that this component of the project permitted an early and continued association with teaching and children allowing participants to make an early assessment as to their desire to stay with teaching as a profession. These eight participants subsequently moved into other academic areas within the university, and later received baccalaureate degrees from Purdue University.

Of the thirty seven graduates of the four year UPSTEP project, three continued their education and enrolled directly in Graduate School. Twenty one former UPSTEP members secured immediate employment for the year 1976-77. Seven members secured teaching positions mid-year, 1976-77. Three members married and moved to university communities such as Ithaca, New York, etc. These graduates were unable to obtain employment. Teaching positions in university communities are always at a premium due to the large supply of teachers who are wives of Graduate Students.

Because of geographic location, grade level (primarily kindergarten/Nursery), or lack of consent from the participants' school principal regarding testing of students, etc. only fifteen of the twenty-one, employed UPSTEP graduates qualified as viable candidates for the final or In-service segment (5th year) of the project.

During Phase II, evaluation of the remaining UPSTEP participants continued. Data was obtained from these sources: 1) UPSTEP participants (seniors - 1975-76 involved in their student-teaching experiences, 2) In-service teachers (UPSTEP graduates, 1976-77), and 3) Elementary school students (students of UPSTEP In-service teachers 1976-77). Tests were administered as follows:

UPSTEP Seniors

Pretest: Fall, 1975

a) Conceptual Systems, Test A (O. J. Harvey)

b) Teacher Concerns Checklist (F. F. Fuller)

c) Bratt Test of Attitude Towards Teaching and Teaching Science (M. Bratt)

ALL UPSTEP Graduates

Posttest: Spring, 1977

a) Conceptual Systems, Test B (O. J. Harvey)

b) Teacher Concerns Checklist (F. F. Fuller)

c) Bratt Test of Attitude Towards Teaching and Teaching Science (M. Bratt)

Students of UPSTEP In-service Teachers

Pretest: Fall, 1976

Science Teaching Checklist (M. Golman)

Posttest: Spring, 1977

Science Teaching Checklist (M. Golman)

BRIEF DESCRIPTION OF THE TESTING INSTRUMENTS

Conceptual Systems, Test A and B (O. J. Harvey)

The Conceptual Systems Test (see Appendix A) was developed by O. J. Harvey (1970) as a means of identifying the belief systems held by individuals. The test consists of twenty-seven items utilizing a Likert-type response sheet. Use of the test correlates highly (0.91) with the finding of the initial interviewers of the test who conducted extensive and time-consuming discussions and interviews with individuals to assess their basic beliefs. The test was selected because of the expediency with which a belief system can be identified and previously identified correlations of the instrument with a teacher's inquiry techniques (Murphy, 1970). The Conceptual Systems Test measures or identifies four belief systems. These four belief systems range from very concrete to very abstract.

Harvey describes the belief categories as follows:

System I is characterized by such things as high concreteness of beliefs; high absolutism toward rules and roles; a strong tendency to view the world in an overly simplistic, either-or, black-white way; a strong belief in supernaturalism and inherent truth; a strongly positive attitude toward tradition and authority; the relative inability to change set or think creatively.

System II persons are characterized as having strong negative attitudes toward institutions, traditions, and social referents; are low in self esteem, highest in alienation and cynicism; needs keenly to trust and rely upon other persons, but fearing to do so because of potential exploitation by others.

A System III belief system is reflected in a strong outward emphasis upon friendship; interpersonal harmony, and mutual aid; manipulates others through establishing dependency but guises this need to control others as a desire and need to help others.

System IV belief system manifests itself in information-seeking, pragmatism, high ability to change set, withstand stress, and behave creatively.

Teacher Concerns Checklist (F. F. Fuller)

Francis Fuller (1969) has suggested that in order to harness motivation for learning in teacher education programs, notice should be taken of the expressed needs and concerns of teachers. She also posits a developmental trend in types of such expressed concerns as the prospective teacher goes through education. Specifically, two types of concerns were identified: concerns about benefit to self and concerns about benefit to students. It was thus hypothesized that concerns about self are less mature than concerns about pupil needs and the latter gradually replace the former as the teacher progresses through teacher training.

The Teacher Concerns Checklist (TCCL) (see Appendix B) was principally the result of Francis Fuller's efforts to assemble an easily administrable, quickly scored instrument which would note the major areas of concern of teachers. The TCCL requires approximately ten minutes to complete. The instrument itself consists of 56 Likert-scaled items. Five categories are considered. These categories are: 1) Concerns about teaching, 2) Concerns about personal adequacy, 3) Concerns about being accepted and liked by pupils, 4) Concerns about the teaching role, and 5) Concerns about the needs of the students. Reliabilities of total scores incorporating five subscales have been established at .82. The pretest and posttest used in this study were identical.

Bratt Test of Attitude Towards Teaching and Teaching Science

A major component of the UPSTEP project was the humanistic approach utilized throughout Phase I (1972-75) and the continued application throughout Phase II (1975-77). This approach consisted of the utilization of a permanent cadre of staff members who, in a variety of changing roles, progressed with the participants throughout their four year undergraduate program. This approach continued into the fifth (In-service) year. The staff constantly addressed themselves to the continued marriage of content acquisition, to continued science methodology, to early and continued field experience with children, to student teaching experiences, and where applicable to the participants' In-service teaching. This continuous staff involvement more closely matched staff responsibility to the end product--the training of outstanding elementary teachers in science. This continued, involved staff teaching and supervision with its continued close association with students and considerations given to individual strengths and weaknesses was studied to determine the impact on science-related attitudes. The instrument used for this part of the analysis was the Bratt Attitude Test (see Appendix C). This test, also known as the BAT test, consists of 60 intellectual and humanistic science and science teaching attitude statements. Response to the items is on a five-point semantic differential scale (strongly agree to strongly disagree). Intellectual attitude statements were based on knowledge pertaining to the teaching of science. Humanistic attitude statements measured emotional feeling towards the interaction between the teacher and student.

Science Teaching Checklist (M. Golman)

The Science Teaching Checklist (Lehman, 1969) was originally designed to assess the inquiry teaching behaviors and interpersonal relations of student teachers as they were involved in the teaching of science. Ratings were made by the students of these student teachers. The instrument as used in this study was a modification of Lehman's Science Teaching Checklist (see Appendix D) by Golman (1973) to include only those questions which assess inquiry behaviors of teachers. In the revised form a reliability coefficient was calculated to be 0.93. The scores of the students of the UPSTEP In-service teachers were averaged, and the average was assigned to that teacher. Pretest and posttest Science Teaching Checklist were compared and differences noted.

RESULTS OF O. J. HARVEY, FRANCIS FULLER, AND M. BRATT TESTS

O. J. Harvey and Francis Fuller Test Results

Pre-posttest comparison of scores and variation for the O. J. Harvey Conceptual Systems and the Teacher Concerns Check List (TCCL) has taken a number of forms; first, as a simple comparison of Fall (1975) and Spring (1977) means. For those subjects upon which pre-post data were available (n=22), the 1975 mean conceptual systems classification was 2.41 and 2.77 for 1977: This may be somewhat misleading as there were no System II classifications for either group. Nevertheless, a t-test for correlated data indicated a slight, but nonsignificant increase over time ($t = -.97$; $df = 21$; $p = .34$ for two-tailed test, 1975 minus 1977 scores). Similarly, a t-test (pooled variance estimate) of means for subjects who had taught in the interim ($n = 14$, $\bar{x} = 3.07$, $s = 1.21$) as opposed to those who had not) $n = 16$, $\bar{x} = 2.31$, $s = 1.39$) was nonsignificant. ($t = 1.59$, $df = 28$, $p = .12$).

Pre-posttest differences on all five scales of the TCCL were nonsignificant. Pre- and posttest group statistics and results of t-tests for correlated data are provided in Table One. However, posttest scores on two scales for students who had taught during the interim differed significantly from those who had not. In-service teachers were significantly ($p<.01$) less concerned about

TABLE 1

TEACHER CONCERNS CHECKLIST

PRE-POST STATISTICS AND t-TESTS FOR

CORRELATED DATA (N = 22)

CONCERNS FOR:		MEAN	S.D.	T-VALUE	df	2-TAIL PROBABILITY
STUDENT ACCEPTANCE	1975	2.545	.863	-1.77	21	.091
	1977	2.895	.765			
BEING OVERWORKED	1975	2.227	.887	- .16	21	.877
	1977	2.257	.810			
STUDENT DEVELOPMENT	1975	3.803	.657	-1.28	21	.215
	1977	3.969	.563			
POWER STRUCTURE	1975	2.742	.872	- .10	21	.923
	1977	2.758	.735			
CURRICULUM INFLEXIBILITY	1975	3.090	.764	- .08	21	.937
	1977	3.106	.717			

being overworked and about curriculum inflexibility ($\underline{p}<.01$). All data concerning in-service and non-service group scores and differences as evaluated via t-tests (pooled variance estimate) are offered in Table Two. The latter finding suggests that extended field experience leads to the attitude that integrated science processes can be taught under many curriculum structures. Those less experienced apparently tend to feel that these processes can only be taught in the most flexible of curricula.

A more revealing analysis is that of the interelationships among the subjects' O. J. Harvey and TCCL scores. Multiple linear regressions (Nie _et al_., 1975) of TCCL subscales on O. J. Harvey classification (OJH) were conducted for 1975 and 1977 data. Regression analysis for the 1975 data produced an equation which utilized only four of the five TCCL subscales with a multiple R of .42 ($n = 27$, $\underline{p}<.05$):

$$\begin{aligned} \text{OJH} = {} & .838 \times \text{Curriculum Inflexibility} \\ & +.767 \times \text{Power Structure} \\ & -.561 \times \text{Overwork} \\ & -.541 \times \text{Student Development} \\ & +1.129 \end{aligned}$$

From these results, one might conclude that measured belief systems conducive to teaching integrated science processes is associated with relatively strong concerns about curricular inflexibility ($r = .28$), power structure ($r = .20$), a lack of concern for work load ($r = -.02$), and student development ($r = .02$). Negative regression weights cannot be construed as strictly

TABLE 2

TEACHER CONCERNS CHECKLIST
IN-SERVICE, NON-SERVICE STATISTICS*
AND t-TESTS (POOLED VARIANCE)

CONCERNS FOR:	GROUP	MEAN	S.D.	T-VALUE	df	2-TAIL PROBABILITY
STUDENT ACCEPTANCE	IN	2.405	.876	-1.37	28	.182
	NON	2.823	.799			
BEING OVERWORKED	IN	1.856	.565	-2.85	28	.008
	NON	2.626	.859			
STUDENT DEVELOPMENT	IN	3.667	.705	-1.68	28	.105
	NON	4.042	.515			
POWER STRUCTURE	IN	2.548	.939	-1.80	28	.082
	NON	3.083	.683			
CURRICULUM INFLEXIBILITY	IN	2.737	.849	-2.79	28	.009
	NON	3.500	.645			

*IN-SERVICE N = 14

NON-SERVICE N = 16

negative relationships as they serve to suppress the overestimating positive weights. Concerns about student acceptance are totally unrelated to belief system for the 1975 data.

A similar analysis was conducted for the 1977 data with surprisingly different results. The final regression equation for these data included all five TCCL subscales and yielded a multiple R of .66 (n = 30, $p < .001$):

$$\begin{aligned} \text{OJH} = & -.871 \times \text{Curriculum Inflexibility} \\ & +.512 \times \text{Student Acceptance} \\ & -.469 \times \text{Power Structure} \\ & +.293 \times \text{Student Development} \\ & -.038 \times \text{Overwork} \\ & +4.340 \end{aligned}$$

These results are startingly dissimilar to the 1975 findings. Belief systems conducive to the teaching of integrated science processes for 1977 data are now related to a characteristic lack of regard for curriculum inflexibility (r = -.57), some need for student acceptance (r = .02), and lack of concern for prevailing power structures (r = -.47), student development (r = -.14), and overwork (r = -.10). Further evidence for the dissimilarity between the two sets of relationships can be found in the fact that the 1977 data fit into the 1975 regression equation yielded a nonsignificant multiple R (R = .007).

What is indicated by these findings is that in the year that followed graduation, belief systems of subjects as a whole changed from a relatively inconsistent amalgam of concerns to one which is certainly more consistent, and for the most part, logically explainable. A troubling finding is the apparently stable lack of concern for student development. Despite this negative relationship, the mean value for concerns in this area (3.87) is not significantly different from the value of the TCCL norm group (3.60).

Bratt Attitude Test (BAT) Results

Pre- and posttest measures on the Bratt Attitude Test (BAT) were available for 24 UPSTEP graduates. Gains for intellectual and humanistic scales were examined by means of t-tests for correlated data (2-tail tests of significance). Tables Three and Four present 1975 and 1977 group statistics and t-test results for intellectual and humanistic scales, respectively. Also provided in each table are parallel treatments of scale components (i.e., positive and negative attitudes). All pre- and posttest comparisons were nonsignificant.

It is clear from these results that there was no substantial change in attitudes, either towards teaching in general or towards science teaching, during the first year after graduation. Apparently, the attitudinal character of the group, largely engendered by the UPSTEP program, is relatively stable.

Science Teaching Checklist Results

The Science Teaching Checklist (Golman, 1973) is a form that assesses student perceptions of inquiry behaviors. Student data were collected from the classes of 10 in-service teachers at the beginning and end of the first year of in-service teaching. Pre- and posttest administration group statistics appear in Table Five.

TABLE 3

BRATT ATTITUDE TEST: INTELLECTUAL SCALE

PRE-POST STATISTICS AND t-TESTS FOR CORRELATED DATA (N = 24)

COMPONENT		MEAN	S.D.	T-VALUE	df	2-TAIL PROBABILITY
POSITIVE ATTITUDES	1975	38.67	4.43	.62	23	.542
	1977	38.21	5.22			
NEGATIVE ATTITUDES	1975	32.79	4.89	-1.65	23	.113
	1977	34.63	5.27			
TOTAL	1975	71.46	8.35	- .93	23	.363
	1977	72.83	8.98			

TABLE 4

BRATT ATTITUDE TEST: HUMANISTIC SCALE

PRE-POST STATISTICS AND t-TESTS FOR CORRELATED DATA (N = 24)

COMPONENT		MEAN	S.D.	T-VALUE	df	2-TAIL PROBABILITY
POSITIVE ATTITUDES	1975	38.38	4.14	.17	23	.867
	1977	38.27	4.59			
NEGATIVE ATTITUDES	1975	29.33	4.05	- .09	23	.932
	1977	29.42	4.81			
TOTAL	1975	67.71	7.09	.01	23	.988
	1977	67.69	7.89			

TABLE 5

STUDENT CONCERNS CHECKLIST

PRE AND POST ADMINISTRATION STATISTICS

SUBJECT	PRETEST			POSTTEST		
	MEAN	S.D.	N	MEAN	S.D.	N
1	15.13	4.70	40	18.68	2.07	37
2	12.59	3.88	22	17.96	2.77	22
3	18.55	3.22	20	18.79	2.74	19
4	23.13	2.45	16	24.67	1.95	15
5	16.90	2.87	40	18.40	2.79	57
6	14.84	2.85	67	20.30	2.81	74
7	18.11	2.69	19	17.19	3.10	16
8	19.40	2.38	25	17.89	3.82	27
9	15.35	2.46	20	15.85	2.82	20
10	17.77	3.81	26	20.31	2.95	26
COMBINED	16.58	4.03	295	19.06	3.30	313

A t-test for correlated data shows that student perceptions of their teachers' inquiry behavior indicate a marked increase in perceived effectiveness ($t = 2.401$, $df = 9$, $p < .05$, two-tailed test).

Summary of Test Results

The collective findings of these previous investigations demonstrate a distinct developmental pattern. Although the overall attitudinal character of UPSTEP graduates did not change significantly in the first year after graduation, specific concerns with respect to teaching did tend to unify into a more consistent system of beliefs. This system is typified by the theoretical formulations of the O. J. Harvey Conceptual Systems Test. Concurrent with this unification is an apparent increase in the ability to teach integrated science skills as perceived by the students of in-service teachers.

INQUIRY EVALUATIONS

Each UPSTEP In-service participant (N = 15) submitted one tape per week over a year's period (1976-77). This approximates 24 In-service tapes - twelve per semester. Each tape submitted was interpreted by each participant as the best lesson taught that week.

These In-service tapes (total of 348 tapes) were evaluated by two trained tape reviewers. The two trained tape reviewers were former public school teachers, one of whom holds a M.S. Degree and the other evaluator holds and Ed. S. Degree in Education. These reviewers previously evaluated approximately 150 Pre-service tapes recorded during the UPSTEP participants' student-teaching experience. These Pre-service tapes were evaluated utilizing an interaction analysis science teaching instrument (G. Hall, see Appendix E). Thus, it was felt that this involvement established with the tape evaluators a well grounded and consonant measure of validity and reliability to evaluate the subsequent Inquiry evaluation tapes.

Initially the In-service participants were requested to submit lessons only in the area of science. Because of numerous constraints such as grade level and curriculum variations of contributing schools, this was not always feasible. While the majority of submitted lessons were from the area of science (approximately 300), many lessons were from the area of social studies, reading, language arts, etc. (approximately 48). This presented the participants with an interesting challenge. Science and social studies lend themselves most readily to Inquiry instruction. This is not necessarily true of other areas of the curriculum. The over-all average Inquiry Rating assigned by the tape evaluators was 4.40 for those lessons identified as science and 3.47 for those lessons identified as non-science.

The evaluated tapes were analyzed to determine the level of inquiry teaching practiced by the UPSTEP In-service participants, see Table Six - Inquiry Evaluations, Participants' Yearly Average 1976-77. Inquiry being defined as the process of seeking information directed towards the resolution of a problem. Inquiry, further defined, is that process which fosters the development of creative, innovative, independent thinkers who, when confronted with a problem, exhibit an autonomous search behavior reflecting their own criteria for assessing the value, accuracy, and relevance of their ideas.

The tape evaluators recorded data in fourteen discrete categories of an optical-scan sheet. At the conclusion of the optical-scan plotting of each tape the tape evaluator, on a scale of 1-10 (ten being an excellent rating), assigns to the lesson her assessment of the general inquiry climate of the lesson. At the end of each tape evaluation, the tape evaluator submits to the participant a general statement as to her reaction to the lesson, constructive criticisms, and suggestions for improvement.

The optical-scan sheets were then fed into the computer utilizing a predetermined criteria (see Inquiry Questions and Answers Program Behavior Categories, DeVito/Mazzuca, Appendix F). Program output is divided into three major categories: 1) Percentage of time spent in questioning and answers, leading the student (teacher giving directions, instructions, etc.), lecturing (direct exposition), student-to-student interaction (experimentation, data collecting, etc.), and non-inquiry behaviors (discipline, classroom announcements, etc.). 2) Number of each type of teacher question. These are divided into five areas--closed recall questions (memory type, convergent), open recall questions (divergent), reasoning questions, evaluative questions, and affective questions. And, 3) Descriptive and evaluative computer statements.

A computer printout for each lesson was returned to each participant noting constructive remarks offered by the director. Table Six, Inquiry Evaluation reflects a summary of the participants' yearly average for all tapes in all fourteen categories plus a summary of descriptive and evaluative computer statements. The participants were ranked by the tape evaluators as to the lesson's inquiry rating (see IR column, Table Six).

Significant Interpretations of Table Six - Inquiry Evaluations, Participants' Yearly Averages 76-77

An analysis of the 348 inquiry tapes evaluated revealed that the UPSTEP participants' tapes averaged 27 minutes in length and that the participants averaged 1.56 questions per minute, over all lessons. Students were ranked by the tape evaluators as the inquiry level of their instruction. The average inquiry rating (IR) was 4.46 on a scale of 1 to 10, ten rated as excellent. Seven participants scored above 4.46. Eight participants scored below 4.46. Observations of the top seven participants' average scores compared to the grand average revealed that these participants taught shorter lessons but provided longer periods of directions to accompany such instruction. In general, the top participants asked fewer questions, in particular fewer recall questions. However, they did ask more affective, convergent, and evaluative questions than their counterparts. Also, these top participants lead their classes more than they lectured, plus their classes reflected higher frequencies of student-to-student verbal interactions.

This assessment was derived from comparing each and every participant to the grand average and determining the number of

TABLE 6

INQUIRY EVALUATION - PARTICIPANTS' YEARLY AVERAGE 76-77 *

PARTICIPANT	TIME	IR	PERCENT OF TIME ENGAGED IN:					TYPE OF QUES & FREQ					DLB/ LB	DC/ PC	CONV/ DIV
			Q&A	DIR	LECT	SI	NIA	CR	OR	REA	AFF	EVA			
Wo	23.9	6.51	52.96	22.03	4.50	16.28	4.22	34.75	10.21	20.05	2.34	.75	1.32	.48	3.19
Hi	29.13	5.71	38.11	25.72	4.61	31.35	.99	17.59	9.50	7.88	4.21	.33	17.02	.24	1.76
Ho	28.25	5.63	48.19	19.76	5.57	24.51	2.50	17.75	6.17	4.25	2.50	1.29	1.86	.98	2.13
Ri	19.0	5.38	56.79	16.10	6.72	15.68	4.69	18.71	5.50	12.21	.75	.34	1.13	.46	1.13
Lo	26.4	5.17	41.84	15.54	4.83	36.02	2.02	7.71	6.09	12.87	6.38	1.46	12.57	.20	0.64
Ep	23.75	5.13	41.75	26.84	5.06	23.90	2.47	10.21	7.88	8.17	1.96	.38	12.92	.45	2.39
Bl	22.71	4.88	40.36	15.19	9.61	32.50	2.35	11.38	3.75	7.13	3.88	1.09	.95	.44	.92
Ca	36.38	4.36	52.52	22.36	12.11	8.91	4.11	48.13	9.30	28.25	.75	.17	.96	.59	3.21
Cl	30.05	4.17	48.59	13.59	3.81	27.71	6.31	31.80	4.13	16.59	.21	.33	.99	.72	2.40
Sm, P.	27.88	4.13	47.83	19.39	7.54	24.11	1.13	15.34	5.92	12.29	1.67	.125	13.84	.32	1.42
Nu	29.29	4.02	52.94	16.51	15.10	13.28	2.19	14.33	4.03	5.28	2.46	1.00	.92	.60	1.19
St	29.33	4.00	46.15	14.42	9.69	26.53	3.22	21.92	3.58	9.92	1.42	0	.67	.46	1.92
Wi	22.42	3.28	62.34	9.53	7.30	13.58	4.04	17.33	2.17	7.67	3.25	.04	.64	.39	3.76
So	30.29	2.96	37.62	15.25	6.94	17.18	23.00	35.25	15.29	10.25	.96	.46	1.10	.34	2.17
Sm, C.	27.40	1.56	60.95	10.10	17.75	7.44	3.76	21.67	4.89	7.11	1.00	0	.86	.38	1.75
GRAND TOTAL	406.18	66.89	728.96	262.33	121.14	318.98	67.0	323.87	98.41	169.92	33.74	7.77	67.75	7.05	29.98
GRAND AVERAGE BASED	27.08	4.46	48.60	17.49	8.08	21.27	4.47	21.60	6.56	11.33	2.25	.52	4.52	.47	2.00

* ON 348 TAPES EVALUATED (23 tapes per participant)

excesses above the average in each category for the top seven as opposed to the bottom seven. In one category Conv/Div (Convergent/Divergent Questions), below 2.00, the lower the stated value the better the rating. Thus, in this category a reduced value was rated as a plus.

Table Seven, UPSTEP Participants' Inquiry Ratings as ranked by Tape Evaluators is a compilation of additional ratio calculations. These are: Ratio of Lecturing/Questions and Answers, Ratio of Student Interaction/Questions and Answers, and Ratio of Reasoning Questions/Total Questions. Additional summations as to the Total Number of Questions, Total Questions/Time, Total Number of Reasoning, Affective and Evaluative Questions, and Total of Affective and Evaluative Questions were added. Previous accumulated ratio data as to DLB/LB and Conv/Div were retained. Also, tape evaluators were identified, grade levels listed, and O. J. Harvey Classifications for each participant recorded. It was felt that this criteria would provide a more detailed profile of Inquiry Teaching. Table Seven retained the tape evaluators rank ordering as to the assigned Inquiry Rating (IR).

Table Eight UPSTEP Participants' Inquiry Rating as ranked by Computer Analysis portrays a new ranking based on the Table VII criteria. Using the group average from Table VII as a pivotal measure, each participant was compared to this base measure in all ten categories. In the comparison of individual participant's scores to the group average in the columns Ratio of SI/Q and A, Ratio of Reas/Total Ques., DLB/LB and DC/PC, a higher score than

TABLE 7

UPSTEP PARTICIPANTS' INQUIRY RATING AS RANKED BY TAPE EVALUATOR

PARTICIPANTS	TAPE EVAL	AV INQ RATING	GRADE LEVEL	O.J. HARVEY CLASS	RATIO OF LECT/ Q&A	RATIO OF SI/ Q&A	TOTAL NO. OF QUES	TOTAL QUES DIVIDED BY TIME	RATIO OF REAS/ TOTAL QUES	TOTAL OF REAS + AFF + EVAL	TOTAL OF AFF & EVAL	DLB/ LB	DC/ PC	CONV/ DIV
Wo	Vicki	6.51	1st	I	.08	.31	68.1	2.9	.29	23.14	3.09	1.32	.48	3.19
Hi	Andrea	5.71	3rd	I	.12	.82	39.51	1.4	.20	12.42	4.54	17.02	.24	1.76
Ho	Vicki	5.63	6th	V (3-4)	.12	.51	31.96	1.1	.13	8.04	3.79	1.86	.98	2.13
Ri	Vicki	5.38	2nd	I	.12	.28	37.51	2.0	.33	13.3	1.09	1.13	.46	1.13
Lo	Andrea	5.17	7th	-	.12	.86	34.51	1.3	.38	20.71	7.84	12.57	.20	.64
Ep	Andrea	5.13	N/K	III	.12	.57	28.6	1.2	.29	10.51	2.34	12.92	.45	2.39
Bl	Andrea	4.88	6th	V (1-3)	.24	.81	27.23	1.2	.26	12.1	4.97	.95	.44	.92
Ca	Vicki	4.36	4th	-	.24	.17	86.6	2.4	.33	29.17	.92	.96	.59	3.21
Cl	Vicki	4.17	5th	I	.08	.57	53.05	1.8	.31	17.12	.54	.99	.72	2.4
Sm, P.	Andrea	4.13	6th	III	.16	.50	35.35	1.3	.35	15.21	2.92	13.84	.32	1.42
Nu	Andrea	4.02	3rd	I	.28	.25	27.1	.93	.19	8.74	3.46	.92	.60	1.19
St	Andrea	4.0	6th	I	.21	.57	36.84	1.3	.27	11.34	1.42	.67	.46	1.92
Wi	Andrea	3.28	3rd	I	.12	.22	30.46	1.4	.25	10.96	3.29	.64	.39	3.76
So	Vicki	2.96	4th	-	.18	.46	62.2	2.1	.16	11.67	1.42	1.1	.34	2.17
Sm, C.	Andrea	1.56	1st	I	.29	.12	34.67	1.3	.21	8.11	1.0	.86	.38	1.75
GROUP AVERAGE		4.46			.17	.44	42.2	1.6 per min	.26	14.17	2.8	4.52	.47	2.00
AVERAGE OF TOP TEN PARTICIPANTS		5.11			.14	.54	44.2	1.7 per min	.29	16.17	3.2	6.36	.49	1.92
AVER OF BOTTOM FIVE PARTICIPANTS		3.16			.22	.32	38.3	1.4 per min	.22	10.16	2.1	.84	.43	2.16

TABLE 8

UPSTEP PARTICIPANTS' INQUIRY RATINGS AS RANKED USING COMPUTER ANALYSIS

PARTI-CIPANTS	TAPE EVAL	AV INQ RATING BY EVAL	GRADE LEVEL	O.J. HARVEY CLASS	RATIO OF LECT/ Q&A	RATIO OF SI/ Q&A	TOTAL NO. OF QUES	TOTAL QUES/ TIME	RATIO OF REAS/ TOTAL QUES	TOTAL OF REAS + AFF + EVAL	TOTAL OF AFF & EVAL	DLB/ LB	DC/ PC	CONV/ DIV	HORIZ SCORE COMP IR
Wo	Vicki	6.51	1st	I	.08	-	68.1	2.9	2.9	23.14	3.09	-	.48	-	7
Lo	Andrea	5.17	7th	-	.12	.86	-	-	.38	20.71	7.84	12.57	-	.64	7
Cl	Vicki	4.17	5th	I	.08	.57	53.05	1.8	.31	17.12	-	-	.72	-	7
Sm, P.	Andrea	4.13	6th	III	.16	.50	-	-	.35	15.21	2.92	13.84	-	1.42	7
Hi	Andrea	5.71	3rd	I	.12	.82	-	-	-	-	4.54	17.02	-	1.76	5
Ca	Vicki	4.36	4th	-	-	-	86.6	2.4	.33	29.17	-	-	.59	-	5
Ho	Vicki	5.63	6th	V (3-4)	.12	.51	-	-	-	-	3.79	-	.98	-	4
Ri	Vicki	5.38	2nd	I	.12	-	-	2.0	.33	-	-	-	-	1.13	4
Ep	Andrea	5.13	N/K	III	.12	.57	-	-	.29	-	-	12.92	-	-	4
Bl	Andrea	4.88	6th	V (1-3)	-	.81	-	-	.26	-	4.97	-	-	.92	4
Nu	Andrea	4.02	3rd	I	-	-	-	-	-	-	3.46	-	.60	1.19	3
St	Andrea	4.0	6th	I	-	.57	-	-	.27	-	-	-	-	1.92	3
So	Vicki	2.96	4th	-	-	.46	62.2	2.1	-	-	-	-	-	-	3
Wi	Andrea	3.28	3rd	I	.12	-	-	-	-	-	3.29	-	-	-	2
Sm, C.	Andrea	1.56	1st	I	-	-	-	-	-	-	-	-	-	1.75	1
GROUP AVERAGE		4.46			.17	.44	42.2	1.6 per min	.26	14.17	2.8	4.52	.47	2.00	4.4
AVERAGE OF TOP SIX PARTICIPANTS		5.01			.13	.54	52.9	1.9 per min	.75	19.63	3.3	7.78	.43	2.10	6.3
AVER OF BOTTOM FIVE PARTICIPANTS		3.16			.32	.32	38.3	1.4 per min	.22	10.16	2.1	.84	.43	2.16	2.4
DIFFERENCE		1.85			.19	.22	14.6	.5 per min	.53	9.47	1.2	6.94	0	.06	3.9

the group average was rated as a plus score. A lower rating than the group average in the columns designated as Ratio of Lect/Q and A and Conv/Div was rated a minus score. The accumulated number of pluses comprise the recorded aggregate Horizontal Score Compilation IR for each participant. Those with the most favorable accumulative scores in the ten categories were re-ranked under the column marked Horizontal Score Computer Inquiry Rating. Seven of the top ten computer IR ranked participants' scores correlated well with the tape evaluators' IR rating scores. The bottom five participants' computer IR scores correlated exactly with the tape evaluators' IR ratings.

In the fall of 1977 a comparison was made between the UPSTEP participants (experimental group, N = 15) and traditionally trained, senior, pre-service elementary education majors (control group, N = 24). During their student teaching experience, the control group was asked to submit audio-taped recordings of five weekly lessons. Each lesson was to represent their best effort for that particular week. The twenty four participants in the control group submitted a total ninety seven tapes. These lessons were analyzed by the previously trained UPSTEP tape evaluators using the same UPSTEP criteria for optical scan plotting and computer analysis. Table 9, Computer Analysis - Comparing UPSTEP Group averages (experimental) to Control Group average records a comparison of the UPSTEP Group using the average of each participants first three tapes plus the average of the yearly total of 348 tapes or approximately 23 tapes per participant.

TABLE 9

COMPUTER ANALYSIS - COMPARING UPSTEP GROUP AVERAGES (EXPERIMENTAL) TO CONTROL GROUP AVERAGE

GROUP	TIME (Min.)	PERCENT OF TIME ENGAGED IN:					TYPE OF QUES & FREQ					DLB/ LB	DC/ PC	CONV/ DIV
		Q&A	DIR	LECT	SI	NIA	CR	OR	REA	AFF	EVA			
UPSTEP (N=15) (based on 348 tapes)	27.1	48.6	17.5	8.08	21.27	4.47	21.6	6.56	11.33	2.25	.52	4.52	.47	2.00
UPSTEP (N=15) (based on 45 tapes)	23.2	52.5	20.5	6.0	16.7	2.5	19.2	9.4	10.0	2.1	1.0	3.5	0.4	1.2
CONTROL (N=24) (based on 97 tapes)	20.97	49.94	19.18	14.78	6.47	11.98	33.7	4.2	7.1	.94	.29	.90	.37	7.71

A summary review of Table 9 reveals that in the "Percent of Time Engaged In" area the UPSTEP participants lectured less, generally spent less time giving directions, and spent an equivalent amount of time engaging in questioning and answering questions compared to their counterparts in the control group. Significantly, the UPSTEP participants allowed more time for student-to-student interaction (experimentation, data collection, etc.) than the control participants. Also, the UPSTEP participants engaged in a significantly lesser amount of time for non-inquiry activities.

In the "Type of Question and Frequency" area the UPSTEP participants used much less Closed Recall questions (CR, memory type, convergent type, etc.), much more Open Recall questions (OR, divergent), Reasoning, Affective, and Evaluative questions than the control participants.

In the "Descriptive and Evaluative Computer Statement" area the UPSTEP participants lead their students more than they lecture to them (DLB/LB, Discrete Leader Behavior to Lecture Behavior) at a much higher ratio than the control participants. In the Delayed Closure to Prompt Closure area (DC/PC) the UPSTEP participants showed little difference from the control participants. The Convergent Question to Divergent Question ratio (Conv/Div) showed the UPSTEP participants to use much less convergent questioning than the control participants. With divergent questioning viewed as a promoter of creative thinking, this action is interpreted as an asset for the UPSTEP participants.

A summary profile of an UPSTEP participant graduate might be reflected in the following description:

> A person exposed to the Purdue University UPSTEP model treatment lectures less, spends less time in the perfunctory tasks of teaching, quickly gets on with the task of teaching, allows students to become thoroughly involved in the learning process, consistently ask higher level questions, and consistently ask divergent questions to stimulate higher level thought.

Summary Comments

Anecdotal plus statistical data appear to support the conclusion that the integrated inquiry approach to the teaching of science to prospective elementary teachers is superior to a fragmented bits and pieces approach to science instruction. It would be difficult to argue that early, continued, and varied field experiences with children tied to appropriate integrated science instruction buttressed by continued pedogogical methodology would not be superior to isolated science content acquisition, topped by a science methods course, and followed by a student teaching experience.

If science instruction in the elementary school is to be improved and if inquiry as a technique for instruction in science and other areas of the curriculum is deemed desirable, this model or a similar model of instruction will need to be implemented. Inquiry cannot be acquired by osmosis. It must be taught and practiced by the instructor. It must be practiced by the learner. And, it must be taught by the learner in the role of an instructor. Inquiry instruction cannot be accomplished in a one or two semester course. Instruction in inquiry must start early in the pre-service education of prospective elementary teachers. And, it must be cultivated and practiced slowly over time. There are few short cuts.

The Purdue University model provides a mechanism. It also provides some supportive data that the model works. It does not, however, provide people. And, people make the model work. The model demands cooperation between vested parties. The model demands sacrifices from areas previously deemed sacrosanct. New priorities must be established. Sometimes these sacrifices are at the expense of expansive science content coverage. Uppermost, the model demands strong leadership. If the Purdue University UPSTEP model is to be successfully implemented and maintained, it will require a program chairperson who, in concert with the participating faculty, constantly monitors the components of the model to maintain the totality of the goals of this approach to learning. Paramount to the goals is the goal of creating individuals who themselves are creative, innovative, independent thinkers who can teach children to be likewise.

APPENDICES

APPENDIX A Conceptual Systems Test, O. J. Harvey

APPENDIX B Teacher Concerns Checklist, F. F. Fuller

APPENDIX C Bratt Attitude Test, M. Bratt

APPENDIX D Science Teaching Checklist, M. Golman

APPENDIX E Interaction Analysis Science Teaching Instruction, G. Hall

APPENDIX F Inquiry Question and Answering Program Behavior Categories, De Vito/Mazzuca

APPENDIX G In-service Summary Report of Inquiry Teaching, UPSTEP Participants

APPENDIX A

PERSONAL OPINION SCALE*

Scale A

The following is a study of what the general public thinks and feels about a number of important social and personal questions. The best answer to each statement below is your personal opinion. We have tried to cover many different and opposing points of view: you may find yourself agreeing strongly with some of the statements, disagreeing just as strongly with others, and perhaps uncertain about others; whether you agree or disagree with any statement, you can be sure that many people feel the same as you do.

Please mark each statement in the parenthesis following the question assigning a value from 1 to 5, depending on how you feel in each case.

1 = I agree completely
2 = I agree mostly (i.e., more than disagree)
3 = I agree and disagree about equally
4 = I disagree mostly (i.e., more than agree)
5 = I disagree completely

1. I think I have more friends than most people I know. ( )
2. Contributing to human welfare is the most satisfying human endeavor. ( )
3. No man can be fully successful in life without belief or faith in divine guidance. ( )
4. I feel like telling other people off when I disagree with them. ( )
5. I like to criticize people who are in a position of authority. ( )
6. I like to join clubs or social groups. ( )
7. Any written work that I do I like to have precise, neat and well organized. ( )
8. It is safest to assume that all people have a vicious streak and it will come out when they are given a chance. ( )
9. I like to have my meals organized and a definite time set aside for eating. ( )
10. I like to do things with my friends rather than by myself. ( )
11. I like to help other people who are less fortunate than I am. ( )
12. I like my friends to confide in me and to tell me their troubles. ( )

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* O. J. Harvey, CST-A 2/71

13. I like to have my work organized and planned before beginning it. ( )

14. I feel like making fun of people who do things that I regard as stupid. ( )

15. Sin is but a cultural concept built by man. ( )

16. I like to keep my things neat and orderly on my desk or workspace. ( )

17. I believe that to attain my goals it is only necessary for me to live as God would have me live. ( )

18. I like to form new friendships. ( )

19. These days a person doesn't really know whom he can count on. ( )

20. Politicians have to bribe people. ( )

21. I like to start conversation. ( )

22. I feel like getting revenge when someone insults me. ( )

23. I like to sympathize with my friends when they are hurt or sick. ( )

24. I like to plan and organize the details of any work I undertake. ( )

25. Guilt results from violation of God's law. ( )

26. I like to give lots of parties. ( )

27. I like to make as many friends as I can. ( )

APPENDIX A

PERSONAL OPINION SCALE*

Scale B

The following is a study of what the general public thinks and feels about a number of important social and personal questions. The best answer to each statement below is your personal opinion. We have tried to cover many different and opposing points of view: you may find yourself agreeing strongly with some of the statements, disagreeing just as strongly with others, and perhaps uncertain about others; whether you agree or disagree with any statement, you can be sure that many people feel the same as you do.

Please mark each statement in the parenthesis following the question assigning a value from 1 to 5, depending on how you feel in each case.

1 = I agree completely
2 = I agree mostly (i.e., more than disagree)
3 = I agree and disagree about equally
4 = I disagree mostly (i.e., more than agree)
5 = I disagree completely

1. I like to meet new people. ( )
2. I feel like telling other people off when I disagree with them. ( )
3. I like to help my friends when they are in trouble. ( )
4. I always like for other people to tell me their problems. ( )
5. I like to criticize people who are in a position of authority. ( )
6. I feel at home with almost everyone and like to participate in what they are doing. ( )
7. In the final analysis events in the world will ultimately be in line with the master plan of God. ( )
8. The dictates of one's religion should be followed with trusting faith. ( )
9. I like to keep my letters, bills, and other papers neatly arranged and filed according to some system. ( )
10. Most people can still be depended upon to come through in a pinch. ( )
11. I like to do things with my friends rather than by myself. ( )
12. I like to have a place for everything and everything in its place. ( )
13. I enjoy very much being a part of a group. ( )

* O. J. Harvey, CST-B 2/71

14. I like to have my life so arranged that it runs smoothly and without much change in plans. ( )

15. I enjoy making sacrifices for the sake of the happiness of others. ( )

16. I feel like making fun of people who do things that I regard as stupid. ( )

17. I prefer to do things alone, rather than with my friends. ( )

18. I find that a well-ordered mode of life with regular hours is suitable to my personality. ( )

19. There are some things which God will never permit man to know. ( )

20. I feel like getting revenge when someone has insulted me. ( )

21. I'm a very sociable person who gets along easily with nearly everyone. ( )

22. I like to treat other people with kindness and sympathy. ( )

23. I don't like for things to be uncertain and unpredictable. ( )

24. You sometimes can't help wondering whether anything's worthwhile anymore. ( )

25. The way to peace in the world is through religion. ( )

26. Anyone who completely trusts anyone else is asking for trouble. ( )

27. Marriage is a divine institution for the glorification of God. ( )

APPENDIX B

TEACHER CONCERNS CHECKLIST

Frances F. Fuller

Research and Development Center for Teacher Education
The University of Texas at Austin

DIRECTIONS: This checklist is designed to explore what teachers are concerned about at different points in their careers. There are, of course, no right or wrong answers; each person has his or her own concerns.

Sometimes people are tempted to answer questions like these in terms of what they think they should be concerned about or expect to be concerned about in the future. This is not what is wanted here. We would like to know only what you are actually concerned about NOW.

On the following pages you will find statements about some concerns you might have now. Read each statement. Then ask yourself: WHEN I THINK ABOUT TEACHING, AM I CONCERNED ABOUT THIS?

If you are not concerned about that now, or the statement does not apply, write the number "1' in the box.

If you are a little concerned, write the number "2" in the box.

If you are moderately concerned, write the number "3" in the box.

If you are very concerned, write the number "4" in the box.

And if you are totally preoccupied with the concern, write the number "5" in the box.

Be sure to answer every item. Begin by completing the following:

1. Name ______________________________ Male________ Female________ Age______

2. Circle the one that best describes your teaching experience:

   1. No education courses and no formal classroom observation or teaching experience
   2. Education courses but no formal observation or teaching experience.
   3. Education courses and observation experience but no teaching
   4. Presently student teaching
   5. Completed student teaching
   6. Presently an inservice teacher

3. If you are a student: Freshman_____ Sophomore_____ Junior_____ Senior_____ Graduate_____

4. The grade level you plan to teach (if student) or are now teaching (if inservice): Preschool_____ Elementary_____ Junior High_____ College_____ Other ______________________________

5. If currently teaching: Average number of students you teach per class: ____________

WHEN I THINK ABOUT TEACHING, AM I CONCERNED ABOUT THIS?

For each statement below, decide which of the following answers best applied to you now. Place the number of the answer in the box at the left of the statement. Please be as accurate as you can.

1 Not concerned
2 A little concerned
3 Moderately concerned
4 Very concerned
5 Totally preoccupied

☐ 1. Lack of respect of some students

☐ 2. Standards and regulations set for teachers

☐ 3. Selecting and teaching content well

☐ 4. The mandated curriculum is not appropriate for all students

☐ 5. Whether students are learning what they should

☐ 6. Whether the students really like me or not

☐ 7. Increasing students' feelings of accomplishment

☐ 8. The nature and quality of instructional materials

☐ 9. Where I stand as a teacher

☐ 10. Motivating students to study

☐ 11. Working productively with other teachers

☐ 12. Lack of instructional materials

☐ 13. Rapid rate of curriculum and instructional change

☐ 14. Feeling under pressure too much of the time

☐ 15. Frustrated by the routine and inflexibility of the situation

☐ 16. Becoming too personally involved with students

☐ 17. Maintaining the appropriate degree of class control

☐ 18. Acceptance as a friend by students

☐ 19. Understanding the principal's policies

☐ 20. The wide range of student achievement

☐ 21. Doing well when a supervisor is present

☐ 22. Meeting the needs of different kinds of students

WHEN I THINK ABOUT TEACHING, AM I CONCERNED ABOUT THIS?

☐ 23. Being fair and impartial

☐ 24. Diagnosing student learning problems

☐ 25. Getting a favorable evaluation of my teaching

☐ 26. Being asked personal questions by my students

☐ 27. Too many noninstructional duties

☐ 28. Insuring that students grasp subject matter fundamentals

☐ 29. Working with too many students each day

☐ 30. Challenging unmotivated students

☐ 31. The values and attitudes of the current generation

☐ 32. Adapting myself to the needs of different students

☐ 33. Whether students can apply what they learn

☐ 34. Understanding the philosophy of the school

☐ 35. Students who disrupt classes

☐ 36. Instilling worthwhile concepts and values

☐ 37. How students feel about me

☐ 38. Student health and nutrition problems that affect learning

☐ 39. The psychological climate of the school

☐ 40. Clarifying the limits of my authority and responsibility

☐ 41. Assessing and reporting student progress

☐ 42. Chronic absence and dropping out of students

☐ 43. Lack of academic freedom

☐ 44. Teaching required content to students of varied background

☐ 45. Student use of drugs

☐ 46. Feeling more adequate as a teacher

☐ 47. Guiding students toward intellectual and emotional growth

☐ 48. Being accepted and respected by professional persons

☐ 49. Adequately presenting all of the required material

☐ 50. Slow progress of certain students

☐ 51. My ability to present ideas to the class

☐ 52. Helping students to value learning

☐ 53. Whether each student is getting what he needs

☐ 54. Increasing my proficiency in content

☐ 55. Recognizing the social and emotional needs of students

☐ 56. The wide diversity of student ethnic and socioeconomic backgrounds

Please use the back of this page for any comments. These may be about the questionnaire in general, about specific items or about any additional concerns you may have.

APPENDIX C

WHAT IS YOUR ATTITUDE TOWARD TEACHING AND TEACHING SCIENCE?

There are some statements about teaching science and teaching in general on the next few pages. Some statements are about a person's feelings about the role of a teacher. Some statements describe how teachers should teach. You may agree with some of the statements and you may disagree with others. That is exactly what you are asked to do. By doing this, you will show your attitudes toward science teaching and teaching in general.

After you have carefully read a statement, decide whether you agree or disagree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. Then find the space on the answer sheet that agrees with your feelings and blacken it.

A = If you agree strongly
B = If you agree mildly
C = If you disagree mildly
D = If you disagree strongly

Example:

00. I would like to make lots of money.

00. ■ B C D

(The person who marked this example agrees strongly that he would like to make lots of money.)

Please respond to each statement and blacken only the space that agrees with your feelings.

Please do not mark in the test booklet.

WHAT IS YOUR ATTITUDE TOWARDS TEACHING SCIENCE?

1. One fact elementary children should learn is that the air is approximately 20% oxygen.

2. Teachers should plan and grade science assignments.

3. Most children should be able to interpret a graph--at least by the sixth grade.

4. Students should design their own science projects.

5. The role of the teacher is to present concepts for the students to learn.

6. A teacher should be a resource person rather than an information giver in science.

7. I should learn as much as the students when I teach.

8. I do not understand science, and I do not want to teach it.

9. The students should progress through science in the sequence I set up.

10. The teacher should tell the children what they have to learn and know.

11. It should be more important to establish a personal relationship with students than worry about the subject matter I transmit.

12. In teaching science, a teacher might spend more time listening to the children than talking to them.

13. Students should not grade their own science projects.

14. The teacher should help the student find ways to attain his own goals, but not set them up for him.

15. Process skills are very important things to be developed in the elementary grades.

16. The teacher should have top priority in decision making over students.

17. The teacher should respond to the student rather than the student responding to the teacher.

18. Students need to know the basic facts of science before they can understand the concepts.

19. Children must learn certain facts in elementary school so they can do well in junior high school.

20. Students should feel that they can sit and discuss any subject at any time with a teacher.

21. I understand science and I want to teach it.

22. Teachers should be solely responsible for assigning student grades in science.

23. In science, children must be told what they are to learn.

24. Students can and should learn to evaluate themselves; teachers should help students do this.

25. The teacher should teach the basic processes of science such as observing, measuring, and classifying in the elementary school.

26. Teachers should teach their specialities.

27. Students and teachers should both be free to express their views in the classroom.

28. The needs of students are irrelevant to teaching; students don't know what they should know.

29. As children experiment, the teacher should act as a guide by asking leading questions.

30. Science is pretty easy to understand.

31. Students should feel that they may discuss their personal goals in a subject matter area with any teacher.

32. Process skills are the most important things to be developed by children in science.

33. The teacher should assign science projects to students.

34. I like science, and I probably am/will be a better science teacher than most other elementary teachers.

35. Students learn best to make decisions when they are given the opportunity to make decisions.

36. I am afraid to teach science because I can't do the experiments myself.

37. The teacher should be accountable for a student's knowledge in science.

38. I just never will understand science.

39. Students and teachers should both respect the knowledge, resourcefulness and creativity of each other.

40. A teacher should teach the basic facts of science.

41. Teachers should cover specific areas in science in each grade.

42. The idea of teaching science scares me.

43. Teachers should tell students about experiments.

44. Students should feel that what they have to say in class is just as important as what the teachers have to say.

45. Students should not plan their own science projects.

46. If an experiment does not come out right, the teacher should tell the children the answer so they will not be lost.

47. Students should learn to evaluate their own science projects.

48. It is a teacher's responsibility to tell children which things are important about science.

49. I do/will not teach very much science.

50. Elementary children should learn how to control variables in an experiment.

51. I feel I am very well prepared to teach science.

52. The teacher should arrange things so that children spend more time experimenting than listening to her in science.

53. Students cannot learn unless they pay attention to what the teacher has to say.

54. I think I understand the work of science.

55. A fact children should know is that blood carries oxygen to the cells--at least by the sixth grade.

56. Students should discover for themselves that learning is their responsibility; teachers should help students learn how to learn.

57. Teachers should help children identify problems.

58. Teachers should not have to be concerned with students' problems.

59. It is important for children to know why iron rusts--at least by the sixth grade.

60. Teachers should teach the students, not the facts of science.

APPENDIX D

Teacher ________________________

SCIENCE TEACHING CHECKLIST*

The Checklist is not a test and is not designed "to grade" either you or your teacher, but to check the usefulness of this technique for assessing what is happening in science classes. Each statement describes some classroom or laboratory teaching activity, or some aspect of teacher-student relationships.

Please read each statement carefully and then give your honest, immediate reaction based on whether or not you feel it accurately describes your class and teacher. A mark in the "Yes" column means you agree that this statement does describe something about your class. A mark in the "No" column indicates that you feel this statement does not describe something about your class. You are not being asked to indicate whether you feel this is the way the class should be taught; only to describe how it actually is being taught now.

Thank you for your cooperation in this study.

Sample Statement:

Yes No
(X) ( ) My teacher has assigned each of us a specific seat in class.

( ) ( ) 1. If a student doesn't quickly answer our teacher's questions, then he (or she) gives us the answer.

( ) ( ) 2. Our teacher frequently gives us his (or her) opinions about what we are studying, and expects us to know them.

( ) ( ) 3. Our teacher tries to help us learn how to ask critical questions of our science readings.

( ) ( ) 4. Our tests usually require us to memorize a large number of facts and definitions.

( ) ( ) 5. Our laboratory work most often comes after discussing and reading about a topic in class.

( ) ( ) 6. We frequently analyze the evidence behind the scientific principles we are studying.

( ) ( ) 7. We occasionally design experiments to find answers to problems.

( ) ( ) 8. Our teacher spends a great deal of our class time going over what we read in a textbook.

* Golman/Lehman

Yes	No		
( )	( )	9.	Our teacher tells us about what science is and what scientists do.
( )	( )	10.	We students usually feel lost when we are doing laboratory work.
( )	( )	11.	Our laboratory work consists of following step-by-step the directions given in a laboratory manual (or by our teacher) to try and get a particular answer.
( )	( )	12.	We are expected to spend most of our time in this class taking notes on what the teacher tells us about a particular topic.
( )	( )	13.	In our laboratory work we usually repeat experiments previously done by scientists to see if we can prove that they were right.
( )	( )	14.	When our teacher asks us a question, he (or she) almost always wants us to give the particular answer he (or she) has in mind.
( )	( )	15.	Frequently our teacher introduces a new topic by starting with some laboratory observations.
( )	( )	16.	We sometimes develop our own model systems to explain some scientific concepts or principles.
( )	( )	17.	Throughout the year, we have had a considerable amount of practice in interpreting data -- analyzing graphs, tables, charts and diagrams.
( )	( )	18.	Our teacher usually asks questions requiring specific one or two replies, or yes-no responses.
( )	( )	19.	Our teacher constantly emphasized our learning general concepts of broad ideas of science.
( )	( )	20.	We learned the scientific method at the first of the year and have not studied it since.
( )	( )	21.	Our teacher usually wants one very specific answer to his (or her) questions.
( )	( )	22.	Our teacher tells us that science can find an answer to any problem.
( )	( )	23.	Our teacher stresses the limitations of science and that scientific theories are tentative explanations.

Yes	No		
☐	☐	24.	We spend much of our class time working on our science vocabulary -- listing and defining new terms.
☐	☐	25.	Our laboratory investigations are closely related to what we are studying in class.
☐	☐	26.	Our teacher frequently asks questions which cause us to pull together and use things we have learned earlier in the year.
☐	☐	27.	Frequently our teacher asks us for our own opinions and ideas.
☐	☐	28.	We sometimes use the laboratory to investigate a problem which a student has brought up.
☐	☐	29.	We frequently practice stating hypotheses and evaluating their usefulness.
☐	☐	30.	We spend most of our time in this class learning facts from some area of science.

APPENDIX E

IAST BASE

INDIRECT

1. Accept feelings: Recognizes and identifies with feelings of students (empathetic), non-evaluative encouragement or joking positive affective response. e.g. "I know this is difficult, but let's try it anyway" (occurs less than 1% of the time).

2. Praise: A positive value judgment. e.g. "That's a good job. Good! Fine!" (Too frequent use makes it invalid).

3. Acceptance of student's statements: A restatement of the student's statement, either written on the board or verbal. This category would also include short, non-evaluative confirmation such as "okay" "all right".

4. Question: All questions which require a student response.

STUDENT-TEACHER

DIRECT

5. Direction: Giving directions and procedures; telling the students how to do something. This required an immediate student response or behavior.

6. Exposition. Initiate substantive information: Lecturing, giving facts, calculating including writing new information on the board, rhetorical questions, and review information would be included in this category.

7. Justification of authority: Disciplinary action and criticism of a student's behavior would be included in this category.

8. Teacher controlled silence: Periods of silence which would include teacher demonstration, or the teacher lecturing, or a teacher examining her notes would be included under this category.

Student Action

9. Student statements: This would include all student statements that are not questions.

10. Student questions: Questions asked by the students of one another or of the teacher would be placed in this category.

11. Affective response: Student responses that reflect student emotions or feelings about a certain topic. (Good or bad)

12. Student activity: This would include activity such as students working in workbooks, reading silently to themselves or working with scientific apparatus, etc.

Student Interaction

13. Division of student-to-student interaction: A mark for the separation between two students' interactions.

14. Nonfunctional behavior: Behavior without direction or purpose where no effective instruction is occurring.

APPENDIX F

INQUIRY Q's & A's PROGRAM
BEHAVIOR CATEGORIES*

	Teacher		Student
A	Closed recall question	H	Closed question
B	Open recall question	I	Open question
C	Reasoning question	J	Relevant answer
D	Evaluation question	K	Unsolicited statement
E	Affective question	L	Statement of Generalization
F	Directions, leading	M	Interaction
G	Exposition, lecturing	N	Non-inquiry behavior

INQUIRY PROGRAM

I. Percentage of time spent in: (Tabular Form)
  1. Questions and Answers
  2. Leading
  3. Lecturing
  4. Student Interaction
  5. Non-inquiry Behavior

II. Number of each type of teacher question (Tabular Form)

III. Descriptive and Evaluative Statements
  1. The ratios of discrete leader-type behaviors to lecture behaviors
  2. The ratio of delayed to prompt closure sequences
  3. Exploring student questions
  4. Degree of generalization attained by students
  5. Student confidence in their own ability
  6. Ratio of convergent to divergent teacher questions
  7. Creative atmosphere

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* De Vito/Mazzuca

APPENDIX G

IN-SERVICE SUMMARY REPORT OF INQUIRY TEACHING

Having gone through four years of undergraduate UPSTEP work at Purdue University, was the fifth year of the project (your teaching evaluations, etc.) of additional values? Yes 12 No _____

Comments

On the first grade level it was sometimes difficult for me to prepare and follow through a strict inquiry lesson, but nevertheless I feel the personal evaluation was very beneficial to me.

I think so. It more or less was the final test as to whether or not everything we had learned, had actually influenced our teaching.

This fifth year of the program proved I could actually, in my own classroom put into practice the ideas of the inquiry approach to teaching. The teaching evaluations from this year showed my strengths and weaknesses. Thus, they helped me realize how I can better myself as a teacher.

Yes, I feel that this fifth year of the program was very valuable. It allowed us to put into use what we picked up the first four years. The weekly reports were helpful in allowing us to see our progress through each semester.

I feel the fifth year was the most important year. With my own classroom I could freely practice my own style while incorporating the inquiry approach. I felt less pressure at this time since I wasn't being observed or graded. I learned more this year about my own teaching habits and inquiry method than the four years of undergradute work.

I believe the fifth year was of additional value because I was able to recapture a lesson after it was over, through listening to the tape. This self-evaluation and also the coaching from the computer sheets and Dr. De Vito were helpful in improving my teaching methods.

The computer printouts and your comments gave good feeback on my lessons. When teaching a lesson I'm not aware of how I spend my time. I don't stop to think--now how much time did I spend asking questions, giving directions, tec. I do feel that it is helpful to know this information and the teaching evaluation was able to point this out along with other useful information.

The fifth year helped me because this was my own class I was working with. I had them every day and not just for an hour. The printouts helped me to see that the first four years of practice worked in real life.

I think the fifth year of UPSTEP was very valuable because it gave us the opportunity to use what we had learned in the most realistic setting of all--our own classrooms!

I felt the fifth year was the most valuable.

Changes Suggested

Not quite as many required tapes.

Adding a math selection to the program - (undergraduate).

More visits in the schools as an undergraduate and in-service teacher (I realize the many problems here!)

Perhaps the graduate student could evaluate his own lessons expressing where he/she felt the strong and weak areas were.

I was interested in knowing how the other graduate students went about teaching the inquiry method.

A little more personal communication for those who live in the area.

I would have liked to have met with someone in the project to discuss my teaching techniques.

Perhaps it would have been helpful to the project member if he/she could have met with the others for a complete explanation of the computer printout. I know I tended to avoid areas which were vague to me.

Include in evaluation what could be done to improve the lesson.

The computer printouts are great. It would have helped me to have them from the very start of the program.

I would hope Dr. De Vito would have been able to visit my classroom, so that he might see what our individual classroom situations were.

I would have liked some sort of explanation or guideline that would have specified exactly what each category on the computer printout meant, perhaps with examples of what "ideal" behavior would be in each category. For example, what kind of student statement shows that the students have confidence in "their own ability and intellectual progress?"

The papers we sent with the tapes left no room for comments to explain what was going on during the lesson.

The tape summary returned to you was comprised of three parts: the written comments, the computer printout, and my written comments. Please rank these three components as to their value to you.

1) most valuable
2) next valuable
3) least valuable

Written Summary

1) most valuable 4
2) next valuable 4
3) least valuable 4

Computer Printout

1) most valuable 1
2) next valuable 5
3) least valuable 6

Director's Comments

1) most valuable 7
2) next valuable 4
3) least valuable 1

The computer printout was divided into three general parts:

1) How you spent the time you alloted to the lesson.
2) The type and frequencies of questions and
3) General statements.

Please rank these three components as to their value to you.

1) most valuable
2) next valuable
3) least valuable

Time Allotment

1) most valuable 5
2) next valuable 3
3) least valuable 3

Type and Frequency of Question

1) most valuable 3
2) next valuable 6
3) least valuable 2

General Statements

1) most valuable 3
2) next valuable 2
3) least valuable 6

One participant ranked each component as equal.

Were all three concerns helpful? Yes 11 No 1

Was your attempts at "Inquiry" teaching well received by the:

Principal ...... Yes 8 No 0 Not Applicable 4

Pupils .... Yes 12 No ____

What subject lended itself best to inquiry teaching? Science 11

Math 1

Social Studies 1

What areas of the curriculum other than science were you able to introduce and use "Inquiry" teaching?

Health 2 Social Studies 4 Language Arts 6 Math 5

Spelling 1 History 2 English 1 Writing 1

Please write a summary reaction of your feelings relative to the contributions (if any) that UPSTEP made to your in-service teaching efforts?

By teaching with the inquiry approach, I was able to bring in a wide variety of activities I most likely would not have tried. Though the children would periodically feel frustrated, they enjoyed these lessons above many others.

Since I did not teach science, I felt it was difficult to show my ability in inquiry teaching--I felt the UPSTEP project was much more valuable to me than the figures on the printouts indicated. I do feel, though, that through this fifth year of UPSTEP, I have developed a basic creative nature of teaching that will hopefully grow in years to come.

I think I was able to try the inquiry teaching because I am free to try many things in my school. Had I been in another teaching situation in this school system, I may have only been allowed to teach traditionally.

I think that UPSTEP reinforced my faith in inquiry teaching. The first year of teaching can be really rough and I appreciated the positive feedback, the constructive criticism helped me key in and try to improve my problems.

This final year of the UPSTEP program was very helpful in getting up and keeping the interest of most students. I found the "inquiry" approach very stimulating to both myself and my students. Many times we may find ourselves in a "slump" as far as good lessons are concerned and this approach (inquiry) along with weekly tapes kept me on my toes and continually thinking of creative lessons, instead of going page by page through the science book.

As a whole the contributions made while we were teaching did not affect me as much as those first four years where the whole idea of inquiry teaching was first shown to us. It was, however, helpful. My situation was rather limiting. Perhaps if I had had an English speaking group, it would have been more helpful still.

There has been personal attention and information given at all times. This has been excellent. Also there has been available equipment and help on lesson planning. I have felt very confident with my students as far as keeping a very open classroom with creativity and inquiry observed at most times. I feel that my background in the program has given me a feeling of confidence and a better preparation for the teaching of science in my class.

Because I knew my lessons were going to be taped and evaluated, I was more aware of the kinds of questions I was asking my class. I also tried to think of inquiry lessons. The UPSTEP project has been very helpful to me. I feel that I have a good foundation on which to build upon in being a better teacher. I find that there is so much to do and not enough time. I need to learn how to use every minute to its fullest. I believe for me the project was successful. I hope that the project will continue. Thank you for all the help you've given me.

The UPSTEP program was one of the few classes that prepared me for the real world. Because it was a five year program, it was the most helpful. I didn't have to listen to theories of teaching. I got to try them out. The program changed my way of thinking in the fact that it doesn't teach facts, facts, facts. It wants to know why, describe, and try your own. It gets the children involved. I am not as uptight if I don't know everything there is to know about a subject. The children and I investigate together and learn together and when we are learning together then when I give the facts and you tell them back to me. I consider myself very lucky to have been in the program and I know I am a much better teacher than if I had taken the other way of teaching science classes at Purdue.

I feel I owe a great deal to UPSTEP. The philosophy of kids involved with learning was not prescribed to by most of the other teachers and they looked at my areas as utter chaos at times, but I truly felt the children learned scientific principles in a fun and rewarding way.

The UPSTEP program let me enjoy science and science teaching as well as the other subjects in a different light. It helped me be freer with creativity and willingness to try out ideas. It helped me to understand and appreciate the total development of the child. It, also, helped me in how to "think" and to teach others how to "think," along with other skills. This was a very worthwhile and enjoyable experience'. I wish other teachers could have this opportunity! Thank you.

I will always be grateful for the training and experience that UPSTEP gave me as an undergraduate. I think it initially gave me an added measure of confidence in the classroom - confidence which I badly needed this first year! The fifth year of UPSTEP has proven to me that inquiry teaching can be used in the classroom; it is not just an impractical theory. This has not been an easy year for me, and if I had not been involved in UPSTEP, I might have been tempted to take the easy route, and teach everything in the traditional way. UPSTEP forced me to use inquiry and now that I have seen it work, I will continue to use it.

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